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THE SYSTEMATICS OF SOME
JAMAICAN EXCAVATING SPONGES
(PORIFERA)

ROSEMARY K. PANG





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THE SYSTEMATICS OF SOME JAMAICAN EXCAVATING SPONGES (PORIFERA)

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ABSTRACT

Thirteen species of coral-dwelling sponges are reported from the reefs of Discovery Bay on the north coast of Jamaica. Seven of these are new species: *Cliona delitrix*, *C. peponaca*, *C. langae*, *C. laticavicola*, *C. aprica* (family Clionidae); *Alectona jamaicensis* (family uncertain); and *Siphonodictyon brevitubulatum* (family Adociidae). Two other species, *Cliona schmidt*i and *C. janitrix*, are new records for the West Indies.

A shallow-water and a deep-water form of two new species are described. Transplant studies indicate that these forms, distinguished by differences in the dimensions of the spicules and papillae, the degree of papillary fusion and, to a slight degree, spicule morphology, are largely habitat-induced. It is suggested that differences in silica concentration with depth may affect spicule sizes.

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I. Introduction

Excavating sponges of the family Clionidae (Subclass Tetractinomorpha, Order Hadromerida, Lévi, 1957) have long been known to exert an important influence on the dissolution and recycling of accumulated calcium carbonate, particularly that from oyster beds and coral reefs. Osler (1826) was the first to recognize the role played by sponges in the destruction of oyster shells. His report appeared only a few months before the genus *Cliona* was established by Grant (1826) for the "new zoophyte", *Cliona celata*, from the oyster beds of the Firth of Forth, Scotland.

Hancock (1849) affirmed that the "new zoophyte", *Cliona celata* Grant, was indeed a sponge and not polyipiferous as Grant had believed. He also stated that *C. celata* was not an isolated, aberrant form but one of numerous species belonging to the genus *Cliona*. Many of his species descriptions, based on dried specimens gathered from the cabinets of British shell collectors, were inadequate. Hancock's type specimens were originally deposited in the Hancock Museum, Newcastle-Upon-Tyne. However, when I visited the museum in August, 1969, Dr. D. Grey, the zoologist, informed me that there were no records of these specimens in the museum. Since Hancock's clionid types are also not deposited at the British Museum (Natural History), it may be assumed that they are lost.

The taxonomic history of the boring or excavating sponges has been both long and complex. The voluminous literature reflects the many controversies and debates that have taken place. More than two hundred species have been attributed to *Cliona* and its synonymous genera (Vosmaer, 1933). Although the establishment of the family Clionidae for the excavating sponges is usually credited to Gray (1867), the name Clionidae was originally proposed by d'Orbigny (1852) for sponges "qui percent l'intérieur des pierres et des coquilles de canaux irreguliers ouverts de distance en distance par des oscules extérieurs" (p. 209). The family contained only the genus *Cliona*. With the addition of several new genera in subsequent years, the family Clionidae may now be divided into two subgroups: (1) *Cliona* and related genera, and (2) *Thoosa* and related genera, distinguished on the basis of differences in microscleres (de Laubenfels, 1936a).

The warm waters of the West Indian coral reefs with their abundance of calcium carbonate substrates in the form of dead bases of living corals, dead corals, calcareous algae, sclerosponges (Hartman and Goreau, 1970) and carbonate rock, would seem to be an extremely favorable environment for the excavating sponges as a group. However, previous investigations (de Laubenfels, 1936a, b, 1949, 1950a, b; Hechtel, 1965) have revealed only four species of clionids in this region. Of these, one is endemic. De Laubenfels (1953a) and Little (1963), working in the Florida Gulf Coast region, reported two and five species of clionids, respectively. Little's fifth species, *Cliona viridis* (Schmidt) Gray, is probably a suberitid (Hechtel, 1965).

By way of contrast, Volz (1939) reported nine (three endemic) species of clionids from the shallow waters of the Adriatic sea, also a warm-water environment with considerable amounts of available carbonate substrate. Studies of the temperate waters of eastern North America by Old (1941, 1942) and Hart-

man (1958) revealed the presence of as many as four species of clionids inhabiting the shells of oysters and other molluscs.

The systematics of the West Indian excavating sponges is largely unknown. The present study enlarges our knowledge of the species occurring in one area of the West Indian region, the reefs of Discovery Bay on the north coast of Jamaica. Although the work of Goreau and Hartman (1963) indicated that below a depth of 15 meters, sponges are an exceedingly important constituent of the north coast reef fauna of Jamaica, there are no previous records of clionids from this area. During the course of the present investigation sponges were collected by hand from depths of 0-50 meters using either free diving with mask, snorkel and fins, or diving with SCUBA equipment. Thirteen species of coral-dwelling sponges are reported; seven of these are new and are described here. The geographical distribution and taxonomic history of the previously described species are given.

Specimens are deposited in the Peabody Museum of Natural History, Yale University, abbreviated as YPM in the text, the British Museum (Natural History), abbreviated as BMNH, and the State University of New York—University of the West Indies Marine Laboratory, Discovery Bay, Jamaica, W.I., abbreviated as SUNY-UWI.

Spicule measurements are reported as mean value with standard error, followed by the absolute range.

II. Previous Records of Excavating Sponges from the West Indies, Florida and the Gulf of Mexico

The shallow waters of the West Indian region possess a rich sponge fauna. Although no previous studies have dealt exclusively with the excavating sponges of this area, thirteen new species of clionids have been described from the West Indies, Florida and the Gulf of Mexico by various investigators. Unfortunately, ten of these species are insufficiently described. The list below summarizes all the previous reports of excavating sponges from this region.

The earliest record of a West Indian clionid is that of Hancock (1849) who described *Cliona millepunctata* from a single dried specimen found inhabiting a West Indian helmet shell, *Cassis tuberosa*. No locality or color was given.

The two new species of the genus *Vioa*, *V. dissociata* and *V. duvernoysii*, reported by Duchassaing de Fonbressin (1850) were described only in terms of the gross morphology of their internal lobes and are thus unrecognizable. It should also be noted that the name *V. duvernoysii* is preoccupied (*V. duvernoysii* Michelin, 1847). The complicated taxonomic history of this name is discussed by Vosmaer (1933).

In their monograph on the sponges of the West Indies, Duchassaing and Michelotti (1864) included several new species of excavating sponges. They also established a new genus, *Euryphylle* (written *Euryphylla* in the explanation of the plates), for excavating sponges inhabiting corals. According to Topsent (1888) this genus is a synonym of *Cliona*. The species descriptions by Duchassaing and Michelotti are too brief to be useful to subsequent workers in the West Indian region. In addition, no reference is made to internal structures: spicular morphology and dimensions or histology. Of the three new species, *Euryphylle dubbia* and *Vioa* (misprinted *Viva* but subsequently corrected to *Vioa*) *strombi* were considered by Vosmaer (1933) to be insufficiently described and, thus, unrecognizable. *V. strombi* was found on *Strombus gigas*. The third species, *Euryphylle latens*, was believed by Topsent (1889) to be, most probably, his *Cliona euryphylle*.

Schmidt (1870) included two new species of his genus *Papillina* in a communication on the sponges of the Atlantic. These species, both from Florida, are *Papillina arenosa* and *Papillina cribraria*. De Laubenfels (1936a) stated that *P. arenosa* is unrecognizable except that it belongs to the genus *Cliona*. *P. cribraria* was placed in synonymy with *Spheciospongia vesparia* (Lamarck) Marshall by de Laubenfels (1932) after he examined Schmidt's type at the Museum of Comparative Anatomy, Harvard University.

Vioa schmidtii from Florida (Ridley, 1881) is not a clionid and should not be confused with *Cliona schmidtii* (Ridley) Topsent.

Topsent (1888) reported specimens of five species of clionids inhabiting shells or corals from the Campeche Bank in the Gulf of Mexico. These sponges, dredged during the cruise of the "Tabasco", are: *Cliona celata* Grant, *Cliona vastifica* Hancock, *Cliona carpenteri* Hancock, *Cliona vermifera* Hancock (from the shell of the spiny oyster, *Spondylus*), and *Cliona euryphylle* (a new species found in coral and in the shell of an undesignated species of *Chama*). In 1889

Topsent enlarged his list of the clionids from the Campeche Bank to include *Cliona johnstoni* (Schmidt) and *Cliona subulata* Sollas, in addition to the above mentioned species. *C. subulata* was synonymized with *Cliona viridis* (Schmidt) Gray by Topsent in 1891. It should be noted, however, that *C. johnstoni* was later removed from the genus by Topsent (1900) and is not now considered to be an excavating sponge. In the second part of his 1889 paper, Topsent reported *C. caribbaea* Carter and *Cliona labyrinthica* Hancock inhabiting specimens of the coral *Porites* from Point à Pitre, Guadeloupe, Leeward Islands, in the Lesser Antilles.

Leidy (1889) believed that his species *Cliona phallica* might be a variety of *Cliona sulphurea* Verrill and noted (1889, 1891) the similarity of *C. sulphurea* to European specimens of *C. celata*. *C. sulphurea* was put into synonymy with *C. celata* by Topsent in 1891. Leidy's *C. phallica*, from Florida, is a massive sponge with tylostyles resembling those of *C. sulphurea* in their shape and size. It is insufficiently described.

Verrill (1907) reported the presence of *Cliona caribbaea* Carter in Bermuda. He also noted the existence of a massive form, with tylostyles but no micro-scleres. Since he believed that this sponge might not be the gamma form of Carter's species, he proposed for it the provisional name *Cliona sordida*. In the same paper, Verrill also proposed a new genus, *Heterocliona* (type species, *Papillina cribraria* Schmidt, 1870) for a massive or goblet-shaped sponge that might have an excavating state when young. *H. cribraria* is perhaps also a synonym of *Spheciospongia vesparia*.

De Laubenfels (1936a) stated that the genus *Cliona* is well represented in the West Indian region and listed the following West Indian species: *Cliona viridis*, *Cliona phallica*, *Cliona subulata*, and *Cliona vermifera*. This list is apparently taken from the literature and not from collections made during the course of de Laubenfels' study. De Laubenfels described *C. caribbaea* in detail, and considered the possibility that it is a variety of *C. celata*. The validity of *C. caribbaea* as a species is discussed in a subsequent section.

Only two species of clionids have been reported previously from Jamaica. They are *Cliona vermifera* and *Cliona viridis*, both found in shallow water near Port Royal on the south coast of the island (Hechtel, 1965). Hechtel also reported the presence of *Anthosigmella varians* (Duch. & Mich.) de Laubenfels in this area. From Bermuda we have another record of *Cliona caribbaea* and the first description of *Cliona lampa* (de Laubenfels, 1950a). De Laubenfels (1949) found *Cliona vastifica* and *A. varians* in the shallow waters of the western Bahamas. He reported *C. caribbaea* from the Panama Canal Zone.

There have been two recent studies of the sponges of the Gulf of Mexico (de Laubenfels, 1954a; Little, 1963). De Laubenfels reported the presence of *Cliona caribbaea* and *C. lampa*. Little found *Cliona truiti* Old, *C. lampa*, *C. celata*, *C. vastifica*, and *C. viridis*. However, the specimens reported as *C. viridis* were misidentified and actually are *Suberites undulatus* George & Wilson (Hechtel, 1965).

Many of the reports of clionids from Florida are from faunal checklists. These include *C. vastifica* from Apalachicola Bay, Florida (Pearse and Wharton, 1938); *C. celata* from Boca Ciega Bay, Florida (Dragovitch and Kelly, 1964), St.

George's Sound, Florida (Menzel, 1956), and the west coast of Florida (Carter, 1885, as *Raphyrus griffithsi*); *C. caribbaea* from Florida Bay (Tabb and Manning, 1961).

Cliona celata has often been reported, as *C. sulphurea*, from the coast of Louisiana in connection with the oyster industry there (Moore, 1899; Cary, 1906a,b, 1907). Hopkins (1956) identified four species of clionids (*C. celata*, *C. lobata*, *C. vastifica* and *C. truiti*) from oyster shells of the Louisiana bays and sought to determine the relative abundance of these species in terms of salinity. His tentative identifications of species from Texas were based on external form and the dimensions of the galleries. Hartman (1958) reported *C. celata* from 1.5 m in Aransas Bay, Texas.

Previous Reports of Clionids and Related Sponges from the West Indies, Florida, and the Gulf of Mexico

WEST INDIES

Jamaica:

Cliona vermifera Hancock, Hechtel, 1965, p. 61

Cliona viridis (Schmidt), Hechtel, 1965, p. 62

Bahamas:

Cliona vastifica Hancock, de Laubenfels, 1949, p. 20

Bermuda:

Cliona lampas de Laubenfels, 1950a, p. 110

Cliona caribbaea Carter, Verrill, 1907, p. 299; de Laubenfels, 1950, p. 108

Cliona sordida Verrill, 1907, p. 299

Guadeloupe:

Cliona caribbaea, Topsent, 1889, p. 49

Cliona labyrinthica Hancock, Topsent, 1889, p. 49

St. Vincent:

Cliona caribbaea Carter, 1882, p. 346

Undesignated locality within the West Indies:

Cliona millepunctata Hancock, 1849, p. 341

Euryphylle dubbia Duch. & Mich., 1864, p. 113

Euryphylle latens Duch. & Mich., 1864, p. 113

Vioa strombi Duch. & Mich., 1864, p. 113

Vioa duvernoysii Duchassaing, 1850, p. 27

Vioa dissociata Duchassaing, 1850, p. 27

FLORIDA

Atlantic coast:

Papillina arenosa Schmidt, 1870, p. 48

Papillina cribraria Schmidt, 1870, p. 48

Dry Tortugas:

Cliona caribbaea, de Laubenfels, 1936a, p. 155

Gulf coast:

Cliona vastifica, Pearse and Wharton, 1938, p. 365

Cliona celata Grant, Dragovich and Kelly, 1964, p. 78, Menzel, 1956, p. 1;

Carter, 1885, p. 207 (as *Raphyrus griffithsi*)

Cliona caribbaea, Tabb and Manning, 1961, p. 542

GULF OF MEXICO

Texas:

Cliona celata, Hartman, 1958, p. 17

Louisiana:

Cliona celata, Hopkins, 1956, p. 49; as *Cliona sulphurea* by Moore, 1899, p. 93, and Cary, 1906a, p. 21; 1906b, p. 50; 1907, p. 28

Cliona vastifica, Hopkins, 1956, p. 49

Cliona lobata Hancock, Hopkins, 1956, p. 49

Cliona truitti Old, Hopkins, 1956, p. 49

Florida, Gulf Coast:

Cliona lampa, de Laubenfels, 1953a, p. 540; Little, 1963, p. 57

Cliona caribbaea, de Laubenfels, 1953a, p. 540

Cliona truitti, Little, 1963, p. 57

Cliona vastifica, Little, 1963, p. 57

Cliona celata, Little, 1963, p. 57

Campeche Bank:

Cliona celata, Topsent, 1888, p. 82; Topsent, 1889, p. 34

Cliona vastifica, Topsent, 1888, p. 82; Topsent, 1889, p. 35

Cliona carpenteri Hancock, Topsent, 1888, p. 82; Topsent, 1889, p. 35

Cliona vermifera, Topsent, 1888, p. 82; Topsent, 1889, p. 35

Cliona euryphylla Topsent, 1888, p. 82; Topsent, 1889, p. 35

Cliona subulata Sollas, Topsent, 1889, p. 34

III. Descriptions of Jamaican Species of Excavating Sponges

Order HADROMERIDA

Family CLIONIDAE

Cliona schmidtii (Ridley) Topsent

Vioa schmidtii Ridley, 1881, p. 130.

Cliona schmidtii, Topsent, 1888, p. 87.

non *Vioa schmidtii* Carter, 1882, p. 348.

Vioa johnstonii var. Schmidt, 1870, pp. 5, 88.

non *Vioa johnstonii* Schmidt, 1862, pp. 78, 83, 86.

Vioa johnstonii Carter, 1882, p. 354.

Color. In life, purple to reddish purple. Underwater the sponge appears bright blue to the diver. After fixation in 10% neutralized formalin and transfer to 70% alcohol, and on after drying, it is dark purple. In acid alcohol (70% EtOH + 30% HCl) the sponge imparts a slight purplish tinge to the solution but retains

Substrates. *Montastrea annularis* (Ellis & Solander), *M. cavernosa* (Linnaeus), *Mussa angulosa* (Pallas), *Porites furcata* Lamarck, *Madracis mirabilis* (Duchassaing & Michelotti), *M. decactis* (Lyman), *Agaricia agaricites* (Linnaeus) forma *agaricites*, *A. agaricites* forma *purpurea*, *Eusmilia fastigiata* (Pallas), dead coral and coral rock.

Depths. Collected from 15–47 m. This species has not been observed to occur above 15 m in the study area, but a specimen inhabiting *Mycetophyllia lamarckiana* Milne-Edwards & Haime was collected from a depth of 58 m on the Discovery Bay reefs (J. C. Lang, unpublished observations).

Material. Sixteen specimens from the reefs of Discovery Bay and Rio Bueno, Jamaica, were studied.

Spicules. (1) Abundant tylostyles straight to slightly curved with globose to subterminal heads and gradually tapering shafts. The heads are 7.9–13.8 μm (= micron) in maximum diameter. The tylostyles (Fig. 1A) are moderately long and rather slender. Tylostyle length: $256 \pm 4.9 \mu\text{m}$, 183–308 μm . Tylostyle width: $5.4 \pm 0.3 \mu\text{m}$, 3.8–9.5 μm . N=8 specimens. Fifty spicules of each category were measured for each specimen. (2) Numerous spirasters of two kinds, both of which are spiny. The short, stout spirasters (Fig. 1C) are straight to slightly curved with prominent spines that are thorny in appearance and irregularly distributed along the length of the axis. Length: $44.8 \pm 1.9 \mu\text{m}$, 26.5–68.9 μm . Width: $5.8 \pm 0.1 \mu\text{m}$, 4.1–7.9 μm . N=8 specimens. The long thin spirasters (Fig. 1B) have 7 to 10 turns to their spire. Their spines are more delicate in appearance and are spirally arranged. Length: $73.9 \pm 1.9 \mu\text{m}$, 60.9–100.7 μm . Width: $2.0 \pm 0.04 \mu\text{m}$, 1.6–3.2 μm . N=8 specimens. The width presented for both categories of spirasters is that of the axis itself without the spines. The absolute ranges of the lengths of these two groups of microscleres overlap somewhat. The means, however, are significantly different. Measurements made on individual specimens show that the longer of the short, stout spirasters are also somewhat thinner and rather resemble the long, thin spirasters in appearance. These may not represent two distinct categories of microscleres.

Surface. The sponge does not encrust its substrate. Ostial and oscular papillae are numerous and separate. Fusion of papillae has not been observed to occur. The perforations in the coral skeleton or coral rock, through which oscular and ostial papillae protrude, form very regular circles of rather variable size. The oscules are shaped like truncated cones and the ostial papillae are low mounds with sievelike surfaces. Both the oscular and ostial papillae are, even when observed in place on the reef and fully expanded, rather low and close to the surface of the substrate. Diameter of ostial perforations: $1.02 \pm 0.12 \text{ mm}$, 0.12–2.46 mm. N=5 specimens. Diameter of oscular perforations: $1.83 \pm 0.30 \text{ mm}$, 0.80–2.40 mm. N=4 specimens. Some of the papillae, particularly the ostial papillae, are quite small (less than 0.5 mm in diameter). These are, most probably, newly formed.

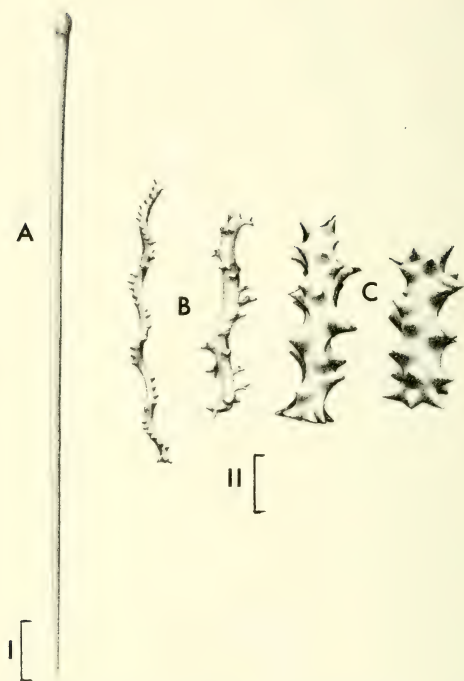


Fig. 1. Spicules of *Cliona schmidtii* (Ridley). A. Tylostyle. B. Thin spirasters. C. Stout spirasters. Scale I (A) = 25 μ m; scale II (B,C) = 10 μ m.

Excavations. The sponge forms spherical or ellipsoidal galleries of rather irregular outline. These galleries lie close to one another with only narrow remnants of the coral skeleton between them. Diameter of the excavations: 1.17 ± 0.06 mm, 0.49–2.64 mm (short diameter), 2.56 ± 0.05 mm, 1.48–3.08 mm (long diameter). N=8 specimens. The tissue of the sponge within the galleries is diaphanous. Upon examination of freshly killed specimens, the tissue is seen to be closely applied to the skeleton of the coral. The channels or tunnels leading from the galleries within the substrate to the surface openings are narrow and irregular.

Internal Structure. The tissue of the sponge is thin and loosely organized. Below the exopinacoderm, the mesohyl has rather large elliptical lacunae ($190\text{ }\mu\text{m}$ by $90\text{ }\mu\text{m}$). The eurypylous choanocyte chambers are $20\text{--}25\text{ }\mu\text{m}$ in diameter. Numerous small ($10\text{--}14\text{ }\mu\text{m}$) pigment cells containing granules that stain darkly with hematoxylin are scattered throughout the tissue. These cells appear capable of assuming a variety of shapes (see Topsent, 1900) and, due to their intrinsic violet coloration, are also clearly visible in unstained sections. Tylostyles and short, stout spirasters lie together in profusion, particularly in the basal region of the papillae. Long, thin spirasters are confined to the choanosome and are most frequently found around the periphery of canals. The short, stout spirasters are the most abundant skeletal elements. Throughout the tissues, groups of highly eosinophilic, globule-containing cells ($12\text{--}15\text{ }\mu\text{m}$ in diameter) with a prominent nucleolus are both numerous and conspicuous. These cells, not described by any previous investigators dealing with *C. schmidtii*, are, perhaps, algal.

Taxonomic Discussion. Specimens of *C. schmidtii* were first reported by Schmidt (1870) as a variety of his *Vioa johnstonii*. Carter (1879) suggested that the two are separate species having in common only their striking purple coloration. Ridley (1881) designated Schmidt's (1870) variety as *V. schmidtii*. *V. johnstonii* is not an excavating sponge and was transferred in 1898 to the genus *Coppatias* (= *Jaspis*) by Topsent. In 1882 Carter unfortunately decided upon *V. johnstonii* as the name for the 1870 variety and used *V. schmidtii* for Schmidt's original species. Ridley (1884) included Carter's 1882 reference in his synonymy but did not mention the discrepancy. Topsent transferred Ridley's *V. schmidtii* to the genus *Cliona* in 1888, but Lendenfeld (1897) continued to refer to this species as *Vioa schmidtii*. A carmine-colored excavating sponge from Australia was designated *Vioa johnstonii* by Carter (1886). This sponge was described by Carter as possessing tylostyles and spirasters. Tylostyle measurements were not given; the tylostyles were neither described nor figured. The spirasters, for which measurements were given, are quite short ($42\text{ }\mu\text{m}$). Topsent (1900) doubted that this is a specimen of *C. schmidtii* (Ridley). The presence of *C. schmidtii* in Australia is therefore questionable.

Geographical Distribution. Mediterranean: Monaco, Topsent, 1934, p. 13; Bonifacio (Corsica), Topsent, 1932, p. 574; Gulf of Gabes (Tunisia), Topsent, 1894, p. 43; *ibid.*, 1934, p. 73; Gulf of Policastro (Italy), Sarà, 1963, p. 209; Banyuls (France), Topsent, 1892, p. xviii. Adriatic: Rovigno, Volz, 1939, p. 16; Lesina, Lendenfeld, 1897, p. 74; Cattaro, Schmidt, 1870, p. 5; Tremiti Island, Sarà, 1961, p. 38. Red Sea: Topsent, 1906, p. 570ff. Indo-Pacific: Eagle Island (Amirante Islands), Ridley, 1884, p. 589; ?Port Western (Australia), Carter, 1886, p. 458; ?Komebail Lagoon (Palau), de Laubenfels, 1954, p. 217.

Previous Descriptions and Discussion. The type of *C. schmidtii* was described from the Adriatic and this species has been reported frequently from the shallow waters of both the Adriatic and Mediterranean seas. Although the Jamaican specimens described above were all collected from relatively deep water (15-

47 m), they agree quite well with those from the Adriatic and Mediterranean. Volz (1939), for example, gave the following dimensions for the spicules of his specimens of *C. schmidtii*: mean length and width of tylostyles, 210–280 μm by 4 μm ; mean length and width of the long, thin spirasters, 70 μm by 2.4 μm . Topsent's (1900) description of the spicular morphology and dimensions, surface morphology, papillary dimensions, and histology of this species also agrees quite well with that presented above for the Jamaican specimens. Previous investigators have all been struck by what Schmidt called the "magnificent violet" color so characteristic of this species. De Laubenfels (1954) reported the presence of *C. schmidtii* from the shallow waters of the west central Pacific. His specimens, however, were brown in life with tylostyles 260 μm by 3 μm in length and spirasters 32–42 μm in length. Some of the shorter spirasters have a spiraled shaft. De Laubenfels stated that they do not appear to be characteristic of the species *C. schmidtii*. Most probably de Laubenfels' specimens are not *C. schmidtii*.

Cliona vermifera Hancock

Cliona vermifera Hancock, 1867, p. 239.

Vioa vermifera, Lendenfeld, 1897, p. 80.

Color. In life, red to red orange. Shallow water specimens (1 m) will appear red orange to the diver while specimens from deeper water (18 m and more) will appear brown. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol the sponge is dark orange yellow. Dried specimens are pale yellow.

Substrates. *Agaricia undata* (Ellis & Solander), *Helioseris cucullata* (Ellis & Solander), dead coral (of the plate-like *Agaricia-Helioseris* type), and coral rock.

Depths. Collected from 1–2 m and 18–52 m. The sponge has not yet been collected from intermediate depths in the study area.

Material. Four specimens from the reefs of Discovery Bay, Jamaica, were studied.

Spicules. (1) Abundant tylostyles (Fig. 2A, B) exhibiting a rather wide range of lengths and widths (141–387 μm by 5.0–10.2 μm) for four specimens. The shorter tylostyles have, for the most part, stout, curved, gradually tapering shafts, and subterminal heads with a maximum diameter of 9.0–11.2 μm . Tylostyle length: $175 \pm 3.1 \mu\text{m}$, 152–187 μm . Tylostyle width: $8.9 \pm 0.22 \mu\text{m}$, 3.1–9.9 μm . N=4 specimens. The longer tylostyles are mostly thinner and straight, tapering toward the pointed end. The head, with a maximum diameter of 7.2–10.8 μm , may be round, slightly elongate or subterminal. Tylostyle length: $287 \pm 2.6 \mu\text{m}$, 195–352 μm . Tylostyle width: $6.1 \pm 0.1 \mu\text{m}$, 5.5–7.7 μm . N=4 specimens. The two categories of tylostyles described above are not com-

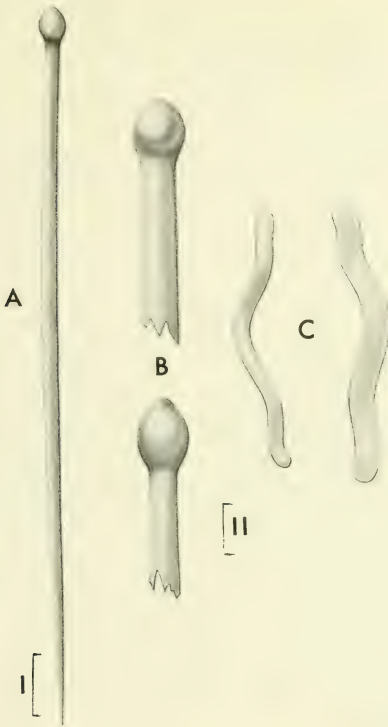


Fig. 2. Spicules of *Cliona vermifera* Hancock. A. Tylostyle. B. Tylostyles, head end enlarged. C. Spirasters. Scale I (A) = 25 μm ; scale II (B,C) = 5 μm .

pletely discontinuous; there are intermediate forms. (2) Numerous smooth, "worm-like" (Carter, 1867, p. 239) spirasters (Fig. 2C) with blunt, rounded ends. Some possess a slight swelling near the central region, but the majority are of a uniform width. Almost all of the spirasters are multiply bent and have from 2–5 turns. A few are arched rather than undulating. Spiraster length: $43.8 \pm 1.2 \mu\text{m}$, 31.8–52.7 μm . Spiraster width: $4.0 \pm 0.2 \mu\text{m}$, 2.2–4.7 μm . N=4 specimens. Each of the four specimens examined possessed some extremely thin spirasters (less than 2 μm in diameter) of normal length. These are presumed to be young stages. Fifty spicules in each category were measured for each specimen.

Surface. The numerous scattered ostial and oscular papillae (Fig. 20) are separate. They form no distinct pattern on the surface of the substrate. Occasional fusion of two ostial papillae may be observed, but the sponge does not tend to overgrow its substrate. Ostial papillae are sievelike in appearance, bearing numerous small ostia. The oscules are shaped like truncated cones. The perforations through which the oscular and ostial papillae protrude are circles, regular and smooth in outline, and are within the same size range. Diameter of ostial perforations: 1.04 ± 0.04 mm, 0.68–1.48 mm (absolute range). N=3 specimens. Diameter of oscular perforations: 1.08 ± 0.04 mm, 0.74–1.54 mm. N=3 specimens.

Excavations. Relatively large galleries not quite completely filled with sponge tissue in the form of rounded to elongated lobes interconnected by numerous slender cylindrical stems. The excavations (Fig. 19) are discrete rather than confluent. This sponge has been found most frequently during the course of the present study in flattened, platelike species of agariciids (*Agaricia undata*, *Helioseris cucullata*) having a thickness of approximately 7 mm or less. In such substrates, the excavations extend nearly from the upper to the lower surface of the coral, leaving very little of the skeleton remaining at either surface. Adjacent galleries are separated by thin remnants of coral and tend to be lined up, one after another, forming a row. Diameter of spherical excavations: 2.64 ± 0.07 mm, 1.11–4.30 mm (absolute range). N=4 specimens. Diameter of the ellipsoidal excavations: 1.64 ± 0.11 mm, 0.98–2.21 mm (short axis); 3.48 ± 0.09 mm, 2.54–5.56 mm (long axis). N=4 specimens. Width of the substrate remaining between adjacent galleries: 0.97 ± 0.10 mm, 0.82–1.20 mm. N=4 specimens. Diameter of interconnecting stems: 0.32 ± 0.08 mm, 0.26–0.51 mm. N=4 specimens. The channels leading from the galleries within the substrate to the surface openings are quite short, about 1–2 mm in length. The degree of excavation of the substrate is usually quite extensive. When an infected coral is viewed in longitudinal section, a row of exposed galleries may be seen extending along the entire length of the cut surface.

Internal Structure. The relatively dense tissue contains numerous tylostyles. The smooth spirasters are found mainly in the basal region of papillae. Numerous eosinophilic, granular cells, 9–12 μ m in diameter, are scattered throughout the internal lobes. Choanocyte chambers are 18 to 20 μ m in diameter.

Taxonomic Discussion. Many clionid species descriptions, particularly those of the earlier workers who often had only dried specimens to examine, are based largely on spicular morphology and dimensions. *C. vermifera* appears to be the only described clionid having a spicular complement composed solely of tylostyles and smooth, stout spirasters. Consequently, this species has had an unusually complicated taxonomic history. It was reported by Lendenfeld (1897) from the Adriatic Sea under the name *Vicia vermifera*. All previous and subsequent reports of this species have been as *C. vermifera*.

Geographical Distribution. Tropical Atlantic: Gulf of Campeche (Mexico), Topsent, 1889, p. 35; Port Royal (Jamaica), Hechtel, 1965, p. 60. Mediterranean: Gulf of Naples, Vosmaer, 1933, p. 565. Adriatic: Lesina, Lendenfeld, 1897, p. 80; Rovigno, Volz, 1939, p. 18. Indo-Pacific: Tuamotu and Gambier archipelagos, Topsent, 1933, p. 565.

It should be noted that Volz (1939) was mistaken in stating that *C. vermifera* was found among a collection of sponges from the West Indies and Acapulco described by Carter (1882). *C. vermifera* appeared in Carter's 1882 communication only as one of a group of sponges he considered as belonging to the family Suberitidae. His purpose in compiling a list of these sponges was to "show that the pin-like skeletal spicule is often accompanied by a spinispirular or other flesh spicule, as well as often without it" (Carter, 1882, p. 354.)

Discussion. *C. vermifera* has been rather infrequently reported. Topsent (1896) found isolated smooth, stout spirasters reminiscent of those of *C. vermifera* and was thus tempted to include this species in his list of Hadromerina from France. In his comprehensive study of 1900, however, he concluded that these spirasters were most likely from *Spiroxya heteroclita* Topsent. Lendenfeld (1897) and Vosmaer (1933) each reported only one specimen, but Volz (1939) found the species to be quite common in the shallow waters in the vicinity of Rovigno. The present study indicates that the species is not common at Discovery Bay, on the north coast of Jamaica. Hechtel (1965) reported only one specimen of this species, from shallow water, at Port Royal on the south coast. Unfortunately, the type locality of *C. vermifera* is not known. Hancock (1897) stated that he examined two specimens inhabiting a species of *Chama*, a eulamellibranch having a very wide geographical distribution. It is also unfortunate that Hancock did not report the range of tylostyle lengths for his type. He gave the tylostyle length as 254 μm . Subsequent workers have found a rather wide range of tylostyle lengths, widths and shapes in individual specimens. Volz (1939), however, reported as megascleres only rather small tylostyles (mean of 175 μm) with subterminal heads; he did not give the range of lengths. It should also be noted that the spirasters of specimens from the Mediterranean and Adriatic (Vosmaer, 1933 and Volz, 1939 respectively) are not as pronouncedly undulating as those described by Hancock and other investigators. However, since the other characters, as described by Topsent, Lendenfeld, Vosmaer, Volz, and Hechtel are all quite similar to those of Hancock's *C. vermifera*, there seems to be no reason to doubt that we are dealing with one widely distributed species. The West Indian specimen figured by Topsent (1900, Plate 1, fig. 4) also possesses the thin spirasters found during the present study. Topsent (1889, 1900) did not, however, mention the presence of a swelling near the central region of the spirasters. This swelling does occur on a few of the spirasters of Hechtel's (1965) specimen. The granular, spherical cells described by Hechtel (1965, p. 60) were also found in the specimens from Discovery Bay.

Cliona janitrix Topsent

Cliona janitrix Topsent, 1932, p. 575.

Color. In life, dull yellow. Underwater, the sponge will appear to be almost colorless to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol it is very pale yellow, almost colorless. Dried specimens are pale yellow.

Substrates. *Acropora cervicornis* (Lamarek), *Madracis mirabilis* (Duch. & Mich.), *Porites furcata* Lamarek, *P. porites* (Pallas), and dead coral (cylindrical, branched pieces).

Depths. Collected from 15–28 m.

Material. Five specimens from the reefs of Discovery Bay and Rio Bueno, Jamaica, were studied.

Spicules. (1) Abundant, slightly curved, moderately stout tylostyles (Fig. 3). The heads are regular in shape having either subterminal or terminally rounded knobs. Maximum knob diameter is 10.9–12.0 μm . The shaft tapers gradually toward the pointed end. This end of the spicule, however, is most irregular in its form. Beginning approximately 30 μm before the termination of the shaft of the majority of the tylostyles there is a series of 2–3 notches, each one diminishing the diameter of the shaft. The pointed tips of the spicules may be irregularly crenulate (Fig. 3). The remainder of the tylostyles taper evenly to about 10 μm above their termination. They then end abruptly in a point of greatly diminished diameter. An enlargement of the axial canal may often be observed in the head region. Tylostyle length: $195 \pm 6.1 \mu\text{m}$, 134–221 μm . Tylostyle width: $9.2 \pm 0.4 \mu\text{m}$, 7.8–11.4 μm . N=5 specimens. Occasional oxeiform spicules occur with both ends showing one or more abrupt reductions in diameter.

Surface. Very small, scattered ostial and oscular papillae not forming any distinct pattern on the surface of the substrate. Papillary fusion has not been observed to occur; the sponge does not overgrow the substrate. Both the ostial and oscular papillae are low, close to the surface and not at all prominent. Fully expanded oscules present the appearance of short cylinders. Ostial papillae are lacy, bearing numerous small ostia. The perforations through which the ostial and oscular papillae protrude are quite circular in their outline. Diameter of the ostial perforations: $0.58 \pm 0.02 \text{ mm}$, 0.37–0.98 mm. N=4 specimens. Diameter of the oscular perforations: $0.70 \pm 0.03 \text{ mm}$, 0.43–0.98 mm. N=4 specimens.

Excavations. The large, spherical to roughly cylindrical galleries are completely filled with the soft, rather delicate tissue of the sponge. Adjacent lobes are connected by flattened stems of varying lengths. Interconnecting stems have not been observed between all the lobes in the same substrate. During the course of the present study, the sponge has been found to inhabit only branched corals

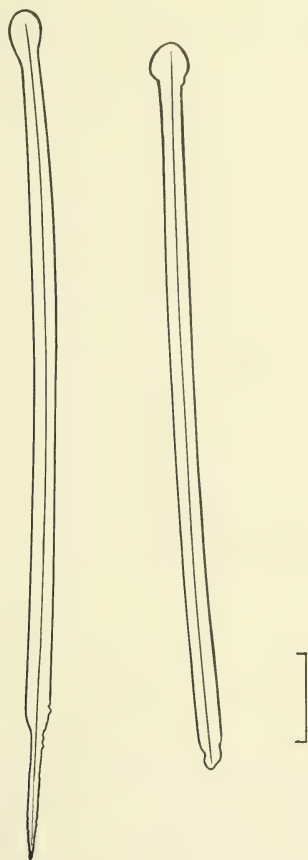


Fig. 3. Tylostyles of *Cliona janitrix* Topsent. Scale = 20 μ m.

of the genera *Porites*, *Madracis* and *Acropora*. In such substrates it may excavate, and completely remove, the central axis of the coral branch. This is particularly true of the specimens inhabiting *Madracis mirabilis*, since branches of this coral are of rather small diameter (usually less than 5 mm). When a coral infected in such a manner is viewed in cross section, a mass of dull yellow tissue may be seen occupying the center of the branch. The channels leading from the

galleries to the surface papillae are quite narrow (approximately 0.5 mm in diameter) and relatively long, averaging 3–4 mm in length. Diameter of the excavations: 5.1 ± 0.2 mm, 3.5–6.0 mm. N=5 specimens.

Geographical Distribution. Mediterranean: Bonifacio (Corsica), Topsent, 1932, p. 575.

Previous Descriptions and Discussion. This species has been reported only once previously (Topsent, 1932). It is listed in Volz's (1939) key as one of the Mediterranean clionids not found during the course of his comprehensive study of the boring sponges at Rovigno. Subsequent workers in the Mediterranean and Adriatic have not reported the presence of *C. janitrix* in these seas (Russ and Rützler, 1959; Rützler, 1965, 1966; Sarà 1959, 1961, 1963; Vacelet, 1960), nor was the sponge reported by Vacelet (1961) in his study of the Demospongiae of Bonifacio, the type locality.

Topsent's specimens are from large fragments of a rather thick oyster valve. Neither the species of oyster nor the depth from which it was collected were presented. The spiculation of his specimens is composed solely of tylostyles. These tylostyles are very close to those of the Jamaican specimens in both their form (fig. vii, p. 575) and their dimensions (180–210 μ m by 8–12 μ m). Topsent stated that both surfaces of the substrate were covered with foreign objects rendering observation of the papillae impossible. The papillae were described merely as small and of ordinary construction; the dimensions were not presented. The galleries (2–3 mm in diameter) excavated by Topsent's species are rounded, spacious and not compactly crowded together.

Cliona lampa de Laubenfels

Cliona lampa de Laubenfels, 1950a, p. 110.

Color. In life, vermilion. Underwater, the sponge appears brown orange to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol it is colorless. Dried specimens are pale brown.

Substrates. *Acropora cervicornis* (Lamarck), *A. palmata* (Lamarck), *Agaricia agaricites* (Linnaeus) forma *agaricites*, *A. agaricites* forma *purpurea*, *Montastrea annularis* (Ellis & Solander), *Solenastrea bourmonii* Milne Edwards & Haime, *Porites astreoides* Lesueur, encrusting coral rock and dead coral.

Depths. Collected from 0.5–36 m.

Material. Twenty-eight specimens from the reefs of Discovery Bay, Jamaica, 1950–1951.

Spicules. 100 to relatively few tylostyles (Fig. 4A) with long, thin, straight shaft tapering gradually to a point. The terminal knobs are round to oval with a

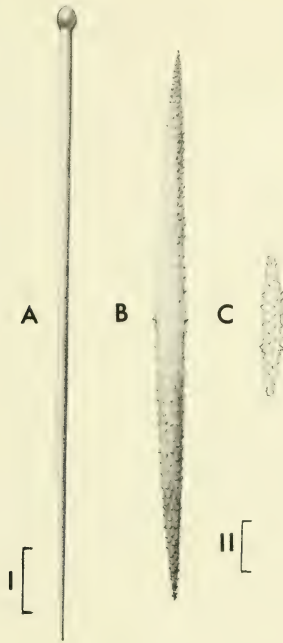


Fig. 4. Spicules of *Cliona lampa* de Laubenfels. A. Tylostyle. B. Microspined oxea. C. Spiny microrhabd. Scale I (A) = 25 μm ; scale II (B,C) = 5 μm .

maximum diameter of 4.9-8.2 μm . Tylostyle length: $280 \pm 4.1 \mu\text{m}$, 236-388 μm . Tylostyle width: $5.1 \pm 0.1 \mu\text{m}$, 4.0-7.1 μm . N=7 specimens. (2) Abundant microspined oxeas (Fig. 4B) often exhibiting a central swelling or possessing more prominent spines in the central region. Oxeas taper gradually from the mid region to the pointed ends. Some oxeas are straight. Oxea length: $79.1 \pm 2.1 \mu\text{m}$, 60-116.3 μm . Oxea width: $3.1 \pm 0.1 \mu\text{m}$, 2.1-4.3 μm . N=7 specimens. It should be noted that oxeas from shallow water specimens (0.5-3 m) were slightly larger (90.5 μm in length, mean of 3 specimens) than those from deeper water specimens (15 m or more). The dimensions of the other two categories of spicules remained constant regardless of depth. (3) Abundant spiny microrhabds (Fig. 4C) that are always straight. Although they are quite small and thin, their spines are more prominent than those of the oxeas. The microrhabds are the most abundant skeletal element. Microrhabd length: $15.2 \pm 0.3 \mu\text{m}$, 9.2-22.1 μm . Microrhabd width: $2.0 \pm 0.1 \mu\text{m}$, 1.1-2.6 μm . N=7 specimens. Both the

oxeas and microrhabds are spined throughout their entire length. Fifty spicules of each category were measured for each specimen considered.

Surface. Ostial and oscular papillae are separate and abundant. Although fusion of two ostial papillae may occasionally be observed, the sponge does not tend to encrust its substrate (see Discussion). The perforations in the substrate through which oscular and ostial papillae protrude are roughly circular in outline. The diameter of the perforations is quite variable. When fully expanded, the oscules (Fig. 17) appear as short cylinders projecting from the surface of the substrate. The ostial papillae are also slightly raised up above the substrate and present a very lacy appearance. Diameter of the ostial perforations: 0.72 ± 0.06 mm, 0.18–1.48 mm. N=16 specimens. Diameter of the oscular perforations: 1.20 ± 0.14 mm, 0.25–3.44 mm. N=15 specimens. The diameter of the papillary perforations appears to be correlated with the age of the sponge and, thus, also with the extent of the excavations. When the sponge is maintained in the laboratory, the oscular papillae are frequently observed to be surrounded by tiny chips of calcium carbonate. The expulsion of these chips from the excurrent openings may occasionally be seen.

Excavations. The spherical to ellipsoidal galleries (Fig. 22), separated from each other by narrow remnants of the coral skeleton, form a honeycombed pattern when viewed in cross section. These galleries (Fig. 18), each completely filled with a mass of soft sponge tissue, are occasionally confluent. The internal lobes of the sponge are interconnected by slender stems (approximately 0.1–0.2 mm in diameter). Diameter of the spherical excavations: 1.05 ± 0.05 mm, 0.31–1.72 mm. N=5 specimens. Diameter of the ellipsoidal excavations: 1.08 ± 0.10 mm, 0.43–2.03 mm (short axis); 1.58 ± 0.10 mm, 0.74–3.08 (long axis). N=8 specimens. Relatively short, wide channels leading to the surface papillae originate at irregular intervals, from individual chambers within the network of galleries. Diameter of the channels: 1.21 ± 0.05 mm, 1.02–1.48 mm. Length of the channels: 3.42 ± 0.09 mm, 3.12–4.23 mm. N=8 specimens. In *Acropora cervicornis*, the excavations may occupy the entire central axis of a branch, to a length of 12–15 cm. In the more massive species of corals the excavations of this sponge are confined to the more superficial layers. This may be related to the channel length of the species.

Internal Structures. The loosely organized tissue of the sponge, apparently lacking species-specific spherular cells, has oxeas strewn in confusion. Although some spiny microrhabds are present in the internal lobes, they are localized in dense bands within the papillae. The relatively scarce tylostyles also contribute to the framework of the papillae. Choanocyte chamber diameter is 14.5–17.4 μ m.

Geographical Distribution. Tropical Atlantic: Bermuda, de Laubenfels, 1950a, p. 110; Gulf of Mexico, de Laubenfels, 1953a, p. 541; Tampa (Florida), Little, 1963, p. 57.

Cliona lampa is apparently confined in its distribution to tropical Atlantic America including the West Indies, Florida and the Gulf of Mexico.

Previous Descriptions And Discussion. Although I have placed the specimens described above in the species *C. lampa*, there do exist some noteworthy differences between these specimens and de Laubenfels' species, *C. lampa*, as originally described by de Laubenfels (1950a) from the shallow waters of Bermuda, "covers the entire surface of the mineral in which it lives" and is not confined to galleries but "penetrates interstices in all directions" (p. 111). De Laubenfels did, however, report the existence of "strands of continuous sponge protoplasm buried in the rocks" that "may correspond to ordinary *Cliona* galleries" (1950a, p. 111).

In the subsequent descriptions of *C. lampa* from the Gulf of Mexico (de Laubenfels, 1953a), Tampa, Florida (Little, 1963), and Bermuda (Neumann, 1966), reference was also made to the ability of this species to permeate its substrate. In addition to this, Neumann (1966) described labyrinthine galleries one or more millimeters in diameter for specimens from Bermuda. Thus far, this habitus of excavating galleries and permeating the substrate has been described for specimens found in aeolian limestone (de Laubenfels, 1950a), *Siderastrea siderea* (Little, 1963), dead coral, porous calcarenite and dense, well-cemented limestone (Neumann, 1966).

The Jamaican specimens discussed above exhibit no tendency to encrust or to permeate the substrate. The sponge is always confined solely to the honeycomb excavations, the channels leading to the surface, and the papillae.

From de Laubenfels' original description, the spicule complement consists of straight tylostyles measuring 3 by 150 μm to 3 by 210 μm ; microspined oxeas, 2 by 70 μm , and microspined streptasters (referred to above as spiny micro-rhabds), 1 by 10 μm . The measurements given by Little are somewhat larger. Tylostyles: 153-210-240 μm by 2-3.9-6 μm . Oxeas: 77-92.0-105 μm by 2-2.4-3 μm . Streptasters: 5-8.1-13 μm by 1-1.9-2.2 μm . Although the microscleres designated "streptasters" by de Laubenfels are straight and rodlike, the term streptaster was originally employed by Sollas (1888) for a category of spiral microscleres to be distinguished from euasters with spines radiating from a central point. This term has since been used in various other ways (see Reid, 1970), notably by de Laubenfels (1950a, 1955) to refer to a "straight rod with long spines or rays" (1955, p. E30). Following the terminology of Sollas, micro-rhabd has been substituted here for de Laubenfels' "streptaster". The tylostyles of the Jamaican specimens are larger and more robust, and spination of the streptasters is more pronounced than those in de Laubenfels' original description. Although the spicules are, in general, larger than those of Little's specimens, the oxeas are somewhat smaller. De Laubenfels did not mention the presence of a central swelling on the oxeas. However, examination of the spicules from a portion of his holotype (BMNH register number 1948.8.6.45) has revealed that many, but not all, of the oxeas do exhibit a central swelling. The same condition has been noted for the Jamaican specimens.

Neither de Laubenfels (1950a, 1953a, b) nor Little (1963) gave descriptions or dimensions of the pores or oscules. Neumann (1966) stated that the oscules are often 3-4 mm in diameter. This figure is somewhat larger than the mean oscular diameter found for the Jamaican specimens. However, a few of these specimens had oscules measuring 2-3 mm in diameter.

Nothing has been reported previously concerning the internal structure of this species.

De Laubenfels gave the color of *C. lampa* in life as "brilliant red, tending toward the vermilion" (1950a, p. 110); Little, "a distinctive brick red" (1963, p. 57); and Neumann, "brilliant vermilion" (1966, p. 102). The Jamaican specimens are vermilion. De Laubenfels further stated that after preservation in alcohol *C. lampa* is "nearly white" and that after drying specimens are "slightly brownish but very pale" (p. 110). Similar conditions are found in the Jamaican specimens, as has been noted above.

According to de Laubenfels (1950a), *C. lampa* is most abundant in areas with strong currents. "For example, at the inlet to Harrington Sound where the water is eternally rushing, either in or out, there are huge areas of this sponge, areas of hundreds of square meters" (p. 110). The Jamaican specimens exhibit no particular preference for areas with fast water movement.

In summary, the spicular morphology of de Laubenfels' *C. lampa* and that of the Jamaican specimens examined during the course of the present study is certainly extremely similar. The spicular dimensions of the latter (except for the oxeas) are somewhat larger. Although the Jamaican specimens do not permeate or encrust their substrates, the boring habit is also similar. Further collections from Bermuda are needed to establish the depth range of *C. lampa* there. It would also be of great interest to determine whether there exist specimens of this species from Bermuda that do not encrust or permeate their substrates. At this time, however, it does not appear that there is sufficient justification for considering the Jamaican specimens as belonging to a new species.

Cliona caribbaea Carter

Cliona caribbaea Carter, 1882, p. 346.

(non) *Cliona caribbaea*, de Laubenfels, 1936a,b; 1950a; 1953a,b; Wells, Wells and Gray, 1960, p. 228.

Cliona viridis, Topsent, 1900, p. 84 (partim).

Cliona viridis, Hechtel, 1965, p. 61.

Cliona viridis var. *caribbaea*, Topsent, 1932, p. 563.

Color. In life, the papillae are yellow; the internal lobes are dull yellow. Underwater, the sponge appears dull yellow to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, it is dark green.

Substrate. *Porites porites* (Pallas).

Depths. Collected from 1–2 m.

Material. Four specimens were collected from the lagoon zone (Kinzie, 1970) of the Discovery Bay reefs. Only small pieces of these specimens were preserved for subsequent spicule preparations.

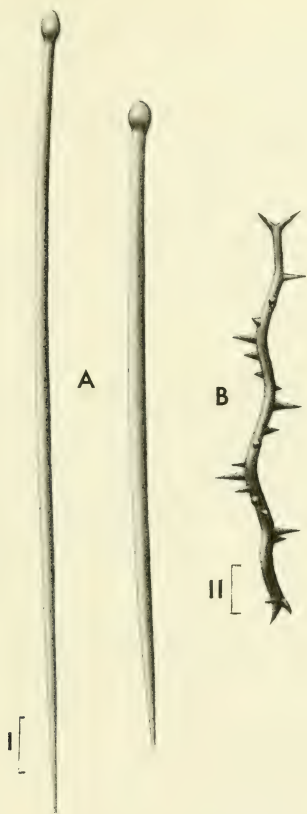


Fig. 5. Spicules of *Cliona caribbaea* Carter. Specimen from Jamaica. A. Tylostyles. B. Spiraster. Scale I (A) = 30 μm ; scale II (B) = 5 μm .

Spicules. (1) Abundant, very long, rather stout tylostyles (Fig. 5A). The shaft, usually slightly curved, but sometimes straight, has its greatest diameter at the midpoint and begins to taper at a point approximately two-thirds of the distance from the head to the tip. The head is elongated, elliptical or, occasionally, spherical. The variation in the form of the knob is not great; it is never sub-terminal. Maximum diameter of the knob is 12.0–16.1 μm ; length is 16.0–18.4 μm . Immediately behind the head of a few tylostyles there may be a secondary annular swelling. Occasionally this swelling occurs further down the shaft.

Tylostyle length: $394 \pm 2.4 \mu\text{m}$, 361–451 μm . Tylostyle width: $10.2 \pm 0.2 \mu\text{m}$, 9.4–12.1 μm . N=3 specimens. (2) Abundant spiny spirasters (Fig. 5B) usually having 2–4 turns. The spines, thornlike in appearance, are spiralled around the axis of the spiraster. Some are very prominent, 3 μm in height. Both ends of the axis bear prominent spines that bifurcate or trifurcate. There are a few rather thin (approximately 1 μm in diameter), almost straight, spirasters with small spines. Spiraster length: $38.3 \pm 1.1 \mu\text{m}$, 27.3–41.8 μm . Spiraster width: $1.5 \pm 0.04 \mu\text{m}$, 1.0–2.2 μm . N=3 specimens.

Surface. The relatively large, scattered ostial and oscular papillae, lying close to the surface of the substrate, are numerous and separate. No papillary fusion was observed. The sponge exhibits no tendency to overgrow the substrate and enter the massive or gamma stage. Measurements of papillary perforations were not made.

Excavations. The galleries are large, cylindrical, ragged in their outline, and not completely filled with the rather tough tissue of the sponge. In the study area, the sponge has thus far only been observed to inhabit branches of the coral *P. porites* (dead basal region of living colonies). In this substrate, *C. caribbaea* produces excavations that completely remove the central axis of the infected branch. The internal lobes of the sponge often bifurcate. Diameter of the excavations: 4.2 mm (mean of three specimens), 3.7–5.8 mm (absolute range of three specimens). Short, wide channels connect the internal lobes with the surface papillae.

Geographical Distribution. Tropical Atlantic: Point à Pitre (Guadeloupe), Topsent, 1889, p. 49; St. Vincent, Carter, 1882, p. 346; Bermuda, Verrill, 1907, p. 299; Port Royal (Jamaica), Hechtel, 1965, p. 61 (as *Cliona viridis*).

This species (*sensu* Carter, 1882) has been reported only from the West Indian region.

Discussion. The question of the validity of Carter's species, *Cliona caribbaea*, presents us with a complex situation. The list of "Previous Reports" above shows that since its original description in 1882 there have been eight reports of *C. caribbaea* from the West Indies, Florida and the Gulf of Mexico. Topsent (1891) placed *C. caribbaea* and *C. subulata* (also reported from the West Indies) in synonymy with *C. viridis* and later (1900, Pl. VII, fig. 2b) figured spicules of his Leeward Islands specimens of *C. caribbaea* as an example of the spiculation of *C. viridis*. Hechtel (1965) also considered *C. caribbaea* and *C. subulata* to be synonyms of *C. viridis* which he reported from Jamaica.

From the original description of *C. subulata* (Sollas, 1878, p. 65), we know only that this species, along with *C. mucronata* Sollas and *C. ensifera* Sollas, was found in excavations in a "patch of *Melobesia*" that was "associated with *Isis*" (p. 65), a gorgonian from an undesignated locality. The spicules, rather thin tylostyles with globose knobs, and spiny spirasters were figured (Pl. II, figs. 26, 27) but not described; no dimensions were given. Because of the brief nature

of the original description, there does not appear to be sufficient evidence to consider *C. caribbaea* to be a junior synonym of *C. subulata*.

C. viridis, originally described from the Adriatic by Schmidt, is quite common in the relatively shallow waters of the Adriatic and Mediterranean Seas (Topsent, 1900; Volz, 1939; Sarà, 1961, 1963, 1965a). The type specimen of *C. viridis*, rather briefly described by Schmidt in 1862, possessed tylostyles with subterminal knobs that are quite distinctive. Tylostyles with the same spatulate heads were observed in a Mediterranean specimen (YPM No. 2896) examined by the present investigator. The spicules of this specimen, both the tylostyles and spirasters, were also quite distinctive. The morphology and dimensions of these spicules are given in Table 1. Topsent's (1900) specimens of *C. viridis* exhibit a great variety in the shape of the head region (it may be subterminal, elongated, elliptical or globose), the color of the sponges in life, the form and length of the spirasters, the arrangement and length of the spiraster spines and the size of the papillae. He apparently included his West Indian specimens of *C. subulata* and *C. caribbaea* in his description of *C. viridis*. Topsent (1900) also described three types of spherular cells that are species-specific for *C. viridis*. He stated that these cells are also present in West Indian specimens of *C. subulata* and *C. caribbaea*. Histological studies of the Jamaican sponge are needed.

The Mediterranean specimens of *C. viridis* exhibit a very pronounced tendency to overgrow the substrate and enter a thickly encrusting stage (Topsent, 1900, and Hartman, pers. comm.). Aside from the gamma stage specimens reported by Verrill, de Laubenfels and Wells *et al.* (discussed below), *C. caribbaea* shows no tendency toward papillary fusion and has not been observed to encrust or overgrow the substrate (Carter, 1882; Topsent, 1889; Hechtel, 1965; Discovery Bay specimens).

The three specimens collected during the course of the present study agree quite well with those described by Hechtel (1965) under the name *C. viridis*. Hechtel also noted the presence of a secondary annular swelling behind the head region of the tylostyles.

Carter (1882) believed that the characteristics of his species were very close to those of *C. celata*, but that *C. caribbaea* could be distinguished from *C. celata* by the spherical head of its tylostyles ("skeletal spicules") and the presence of spirasters ("flesh spicules"). Dr. W.D. Hartman kindly provided a spicule slide prepared from a fragment of Carter's type deposited in the City of Liverpool Museums. See Figure 6.

As mentioned previously, de Laubenfels (1936a,b, 1950a, 1953a,b) did not report the presence of spirasters in his specimens. The length of the tylostyles is also somewhat less than that of the type. De Laubenfels stated that the sponge may often reach the massive or gamma stage. The specimen he described from Dry Tortugas came from deep water (70 m) and inhabited extremely wide galleries not completely filled by the tissue of the sponge. It is doubtful whether any of these specimens (from Dry Tortugas, Panama, Bermuda and the Gulf of Mexico) are actually attributable to the species described by Carter.

Verrill (1907) stated that young individuals of *C. caribbaea* from Bermuda "excavate extensive and irregular cavities in shells and corals, especially *Porites*"

Table 1. Spiculation, excavations and color of *Cliona caribbaea* (Carter, 1882), *C. caribbaea* (Discovery Bay specimens), *C. viridis* from Port Royal (Hechtel, 1965) and *C. viridis* from the Mediterranean.

	<i>C. caribbaea</i> (type specimen)	<i>C. caribbaea</i> (Discovery Bay)	<i>C. viridis</i> (Port Royal)	<i>C. viridis</i> (Mediterranean)
Polystyle dimensions	400 μ m by 10 μ m (369-411-459 μ m by 9.0-10.5-11.2 μ m)*	361-394-451 μ m by 9.4-10.2-12.1 μ m	195-384 μ m by 5-12 μ m	400 μ m† (boring state) (269-532-592 μ m by 10.4-11.7-13.2)†
Tylostyle morphology	Spherical head, fusiform shaft, curved	Head elliptical to spherical, shaft fusiform, curved	Head spherical to ovoid, shaft straight to curved	Spatulate to elliptical head \bar{f}
Spiraster dimensions	30 μ m (27.0-29.2-34.7 μ m by 1.0-1.3-1.5 μ m)*	27.3-38.3-41.8 μ m by 1.0-1.5-2.2 μ m	20-48 μ m by 1-2 μ m	29.4-42.3-52.3 μ m by 1.0-1.7-2.0 μ m†
Spiraster morphology	Slender, 5-6 bends	4-8 bends, slender, thorny spines on convex side	Spines more prominent on convex side, 1-7 bends	2-4 bends, spiny†
Gallery dimensions	Not given	3.7-4.2-5.8 mm	1-3 mm	0.3-1.0 mm‡
Gallery morphology	Cavernous, ragged	Large, cylindrical, ragged	Not given	Not given by Topsent or Schmidt
Color	Ochraceous yellow	Papillae yellow in life	Papillae yellow in life	Dark green \bar{f}

*Measurements from a fragment of the type specimen

†Measurements from gamma stage Mediterranean specimen (YPM No. 2896, Banyuls, France)

‡Topsent, 1900

\bar{f} Schmidt, 1862

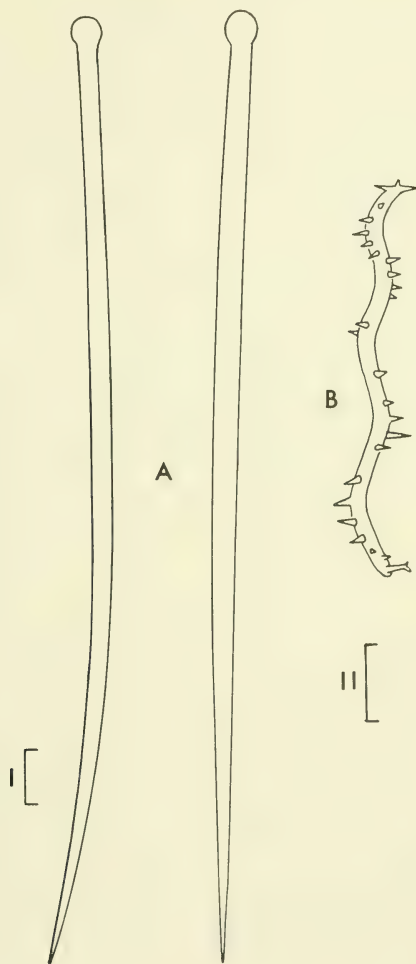


Fig. 6. Spicules of *Cliona caribbaea* Carter. Holotype from St. Vincent, W.I. A. Tylostyles. B. Spiraster. Scale I (A) = 25 μm ; scale II (B) = 5 μm .

(p. 299). His massive specimens, given the provisional name *C. sordida*, possessing no microscleres, are most probably not clionids.

Tabb and Manning (1961) gave no description of their specimens of *C. caribbaea* from the gulf coast of Florida, but stated that de Laubenfels' papers on the West Indian Porifera were used to identify sponges found during the course of their study.

C. caribbaea, again in the gamma stage, was reported from North Carolina by Wells, Wells and Gray (1960). The specimens, bright orange-yellow in life and dark brown after preservation, do not possess spirasters. The surface "exhibits many prominent circular areas about 5 mm in diameter. These probably represent low papillae that have contracted." (p. 230). These specimens are most probably not *C. caribbaea*.

Table 1 compares the spicular morphology and dimensions, shape and dimensions of the excavations, and the color of the type of *C. caribbaea*, *C. viridis* from the Mediterranean, *C. viridis* from Jamaica (Hechtel's specimens), and the specimens collected during the course of the present study.

Carter's *C. caribbaea* is doubtless very close to Schmidt's *C. viridis*. However, since differences, as presented above and in Table 1 do exist, it is deemed best to retain Carter's species, at least tentatively, for the widely distributed West Indian clionid. The relatively recent identifications of *C. caribbaea* by de Laubenfels and Wells *et al.* are misleading and care should be taken by investigators using these sources as a guide to the identification of West Indian clionids.

***Cliona delitrix*, n. sp.**

Diagnosis. A very destructive species that always encrusts the surface of its substrate with a thin layer of red to red-orange tissue. The surface of the sponge, most frequently elliptical in outline with a maximum diameter of nearly one meter, is dotted with small white zoanthids. White areas of dead coral surround the periphery of the sponge. The oscules are large and prominent. The spiculation is composed solely of rather long straight to slightly curved tylostyles, 279 μ m by 8.9 μ m (mean length by mean width of six specimens). Long cylindrical galleries, approximately 4 mm in width, extend directly from the encrusting surface to a depth of as much as 10–12 cm within the substrate.

Color. In life, the surface is red to red-orange; the internal portions are vermilion. Underwater, the sponge appears brown to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, it is orange brown. Dried specimens are cinnamon in color.

Substrates. *Diploria labyrinthiformis* (Linnaeus), *Siderastrea siderea* (Ellis & Solander), *Montastrea cavernosa* (Linnaeus) and dead coral (massive heads).

Depths. Collected from 22–34 m. This sponge has not been observed to occur above 22 m in the study area. It has, however, been collected by the late Prof. T.F. Goreau at 12 m from Maiden Cay, near Port Royal, Jamaica (YPM No. 4611).

Spicules. (1) Abundant tylostyles (Fig. 7), most with a long, thick shaft tapering slightly toward the pointed end. A few tylostyles are rather slender (5–6 μm in width). Most of the tylostyles are straight; some may be slightly curved. Two categories of heads may be distinguished. A) Heads bearing subterminal knobs with a maximal diameter of 8.1–10.9 μm . These knobs are quite irregular in shape. Often the knob is developed on only one side of the head. B) Elongate, slightly developed heads with a maximum diameter of 7.3–9.8 μm . Some of



Fig. 7. Tylostyles of *Cliona delitrix* n. sp. Scale = 25 μm .

these spicules possess a head region so indistinctly separated from the shaft that they tend toward being styles. Occasionally, there is a swelling behind the head region near the center of the shaft. Tylostyle length: $279 \pm 4.6 \mu\text{m}$, 205–321 μm . N=6 specimens. Tylostyle width: $8.9 \pm 0.1 \mu\text{m}$, 5.1–10.7 μm . N=6 specimens. Fifty spicules were measured for each specimen. (2) No micro-scleres were observed.

Surface. This sponge always tends to overgrow the surface of its substrate but has not been observed to extend up above the substrate as do the gamma stages of *C. celata* or *C. viridis*. Only a thin layer of tissue overlies the surface. In the early stages, *C. delirix* forms discrete ostial and oscular papillae but quickly begins to overgrow the substrate. When the sponge inhabits large coral heads, such as *Siderastrea siderea* or *Diploria labyrinthiformis*, it is elliptical in outline, may reach a diameter of nearly one meter (long axis), and occupies the central region of the coral. White areas of dead coral are seen around the periphery of the sponge. It appears that this sponge, once established on a coral colony, expands by actively killing the coral immediately surrounding it. Species of coral with smaller heads may become completely overgrown and, thus, unrecognizable. The oscular papillae are quite large and the oscules are prominent. Fully expanded oscules (Fig. 25) may attain a diameter of nearly 1 cm. There may either be discrete ostial papillae raised slightly above the surface of the sponge or the entire surface, with the exception of the oscular papillae, may be covered with ostia. The latter case is more common in older specimens. Diameter of elliptical oscular papillae: $7.85 \pm 0.14 \text{ mm}$, 7.44–8.21 mm (short axis); $9.65 \pm 0.10 \text{ mm}$, 8.88–9.92 mm (long axis). N=4 specimens. Diameter of circular ostial papillae $1.33 \pm 0.04 \text{ mm}$, 1.26–1.41 mm. N=3 specimens. Diameter of elliptical ostial papillae: $3.05 \pm 0.09 \text{ mm}$, 2.79–3.21 mm (short axis); $4.05 \pm 0.07 \text{ mm}$, 3.89–4.25 mm (long axis). N=4 specimens. The surface of most specimens is dotted with numerous individuals of the small, white zoanthid, *Parazoanthus parasiticus* (Duch. & Mich.) Verrill (Fig. 25). This zoanthid has been previously reported in association with sponges from Bermuda (Verrill, 1900), the Bahamas (Duerden, 1903), Jamaica (Duerden, 1900, as *Parazoanthus separatus*), and the lesser Antilles (Duch. & Mich., 1860, as *Zoanthus parasiticus*). The column has a diameter of 2–3 mm; its walls, particularly toward the base, are impregnated with pieces of debris, sponge spicules and, in this case, calcium carbonate chips extruded by the host sponge. The density of inclusions in the column wall of the retracted polyp causes the tissues to be "firm and opaque white" (Duerden, 1903, p. 500). When, however, the polyps are fully expanded, these tissues are "quite delicate and transparent to a degree probably not met with elsewhere among the zoanthids" (p. 500). The short tentacles appear light brown in color due to the presence of zooxanthellae. Zoanthids are absent from the smaller, and presumably younger, specimens of this sponge.

Excavations. Long cylindrical galleries, all oriented in a direction perpendicular to the surface of the infected coral, may be seen extending directly from the encrusted surface downward into the substrate. The sponge completely fills the galleries it produces but is not confined to them; it also lines those portions of

the substrate remaining between the galleries with a thin layer of its tissue. Below the oscular papillae, nearly 3 cm of the corallum may be removed. The partitions between adjacent galleries of large, older specimens are often removed by the sponge. When the flesh of the sponge is removed with sodium hypochlorite solution, the remaining coral skeleton is lacy and very thin. This species apparently excavates the tabular endothecal dissepiments and occupies the central axis of the corallites constructed by individual polyps. The coral remnants between corallites are pierced by circular holes, of varying sizes, through which the lobes of the sponge are interconnected in life. Thus, when coral heads infected in such a manner are viewed in longitudinal section, the entire skeleton appears vermilion to a depth of as much as 10–12 cm. The structure of the skeleton is greatly weakened by the activity of this extremely destructive clonid.

Internal Structure. The abundant tylostyles, scattered throughout the rather loosely organized tissue, are oriented parallel to the surface in the mesohyl. In this region, there are large elliptical lacunae (303 μm by 101 μm). Granular golden brown pigment cells are very abundant, particularly in the exopinacoderm. These cells (12–15 μm in their larger diameter) appear capable of assuming a variety of forms and in this respect are reminiscent of the pigment bearing “cellules spheruleuses” described by Topsent (1900) for *C. schmidtii*. Choanocyte chambers are 23–27 μm in diameter.

Holotype. YPM No. 8715. Discovery Bay, Jamaica. Inhabiting *Siderastrea sidera* from 37 m. Collected by R.S. Jackson and R. Keeley, Oct. 21, 1968. Repositories of paratypical material: BMNH and SUNY-UW1. Eight specimens from the Discovery Bay reefs were studied.

Comparison With Other Species Of The Genus *Cliona*. In its habit of overgrowing large areas of the surface of the substrate and of lining the substrate remaining between adjacent galleries with a thin layer of tissue, *C. delirix* is similar to the Bermudan specimens of *C. lampa*. Both exhibit beta but not gamma stages of development. However, the two have quite different complements of spicules. Most species of the genus *Cliona* possess tylostyles with well-defined globose or subterminal knobs. Many of the tylostyles of *C. delirix* have elongate, slightly developed heads. A few are styles. *C. lesueuri* (Topsent, 1888, pp. 80, 88, pl. VII, fig. 8) also has large tylostyles with little or no development of the head region, but possesses spirasters in addition and does not encrust. The pattern of the galleries is also different from that of *C. delirix*. The removal of endothecal dissepiments of individual polyps, a boring habit characteristic of *C. delirix*, is believed to be unique among the clonids thus far described.

Remarks. The specific name is from the feminine Latin noun *delirix* meaning “a destroyer”.

***Cliona peponaca*, n. sp.**

Diagnosis. This species, exhibiting no tendency to overgrow the substrate, possesses numerous separate oscular and ostial papillae with the former nearly twice as large as the latter. The spiculation is composed solely of moderately long, stout, slightly curved tylostyles, most bearing subterminal knobs. Tylostyle dimensions are: $243\ \mu\text{m}$ by $3.9\ \mu\text{m}$ (mean length by mean width of four specimens). Papillae and internal lobes are pumpkin-colored (light orange) in life. Relatively large, cylindrical galleries, approximately 1.2 cm in diameter, lying one after another, are interconnected by slender strands of tissue.

Color. In life, the papillae and internal lobes are pumpkin-colored (light orange). Underwater the sponge appears brown to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, it is dark orange-brown.

Substrates. *Acropora cervicornis* (Lamarck), *Porites furcata* (Lamarck), and *Agaricia agaricites* (Linnaeus) forma *agaricites* encrusting coral rock.

Depths. Collected from approximately 15 to 29m.

Spicules. (1) The abundant tylostyles (Fig. 8) are moderately long and stout; most have a slightly curved shaft, but some are straight. The head is most frequently subterminal with a maximum diameter of $8.2\text{--}9.6\ \mu\text{m}$. The knob is symmetrical and always appears to be equally developed on either side of the shaft. The tip is blunt and rounded. Occasionally it is quite elongated, and the knob is set back along the shaft a distance of approximately $10\text{--}12\ \mu\text{m}$. A few spicules have terminal, globose knobs. The shaft increases slightly and very gradually in diameter to a point slightly behind the midregion of the spicule. It then tapers gradually to the pointed end. Tylostyle length: $243 \pm 2.6\ \mu\text{m}$, $207\text{--}269\ \mu\text{m}$, $N=4$ specimens. Tylostyle width: $8.9 \pm 0.1\ \mu\text{m}$, $7.2\text{--}9.4\ \mu\text{m}$. Fifty spicules were measured for each specimen considered. (2) No microscleres were observed to be present.

Surface. Specimens of this sponge exhibited no tendency to undergo papillary fusion or to overgrow the surface of the substrate. Ostial and oscular papillae are numerous and always appear to be separate. Ostial papillae are quite small; the oscular papillae are, on the average, nearly twice as large. The perforations through which ostial and oscular papillae protrude are circular in outline. The papillae are fairly abundant but form no distinct pattern over the surface of the substrate. Ocular papillae bear centrally located oscules that are short and cylindrical, having a diameter of $0.9\text{--}1.0\ \text{mm}$ when they are fully expanded. Ostial papillae are low and sievelike. Diameter of ostial perforations: $0.69 \pm 0.07\ \text{mm}$, $0.49\text{--}0.96\ \text{mm}$, $N=4$ specimens. Diameter of oscular perforations: $1.1 \pm 0.1\ \text{mm}$, $0.72\text{--}1.35\ \text{mm}$, $N=4$ specimens.

Excavations. The large, cylindrical excavations, completely filled with the soft tissue of the sponge, are interconnected by slender strands of tissue. When an

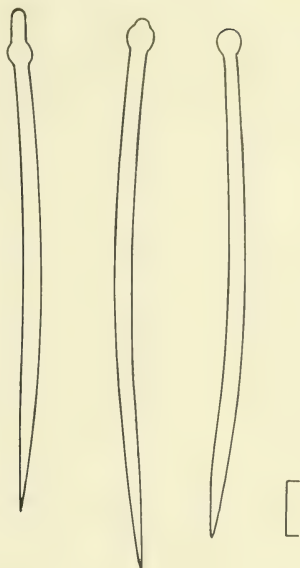


Fig. 8. Tylostyles of *Cliona peponaca* n. sp. Scale = 25 μ m.

infected coral is viewed in cross section, the excavations may be seen to occur side by side, separated by rather thick (2-3 mm wide) pieces of the coral skeleton. In branches of *Acropora cervicornis* or *Porites furcata* two galleries are usually seen in cross section whereas in colonies of *Agaricia agaricites* forma *agaricites* there are often 4-5 consecutive galleries. The galleries in the latter substrate are somewhat elongated compared to those in *A. cervicornis* or *P. furcata*. The lobes of the sponge extend back into their substrate a distance of 0.8-0.9 cm. Diameter of the galleries in *A. cervicornis* and *P. furcata*: 1.2 ± 0.2 mm, 0.9-1.5 mm. N=3 specimens. Diameter of the galleries in *A. agaricites*: 1.4 ± 0.4 mm, 1.1-1.7 mm (long axis); 0.74 ± 0.1 mm, 0.69-0.89 mm (short axis). N=1 specimen. The channels or tunnels leading from the galleries within the substrate are rather wide and short.

Holotype. YPM No. 8719. Inhabiting *Agaricia agaricites* forma *agaricites* encrusting coral rock at 27 m, Discovery Bay, Jamaica. Collected by R. Keeley Pang, Nov. 17, 1969. Repositories of paratypical material: BMNH and SUNY-UWI. Six specimens from the Discovery Bay reefs were studied.

Comparison With Other Species Of The Genus *Cliona*. Topsent's (1891) fifth category of clionids with a spiculation composed solely of tylostyles includes eight species, all described by Hancock: *C. alderi*, *C. gorgonoides*, *C. angulata*, *C. radiata*, *C. globulifera*, *C. quadrata*, *C. insidiosa*, and *C. millepunctata*. The first six of these have been placed in synonymy with *C. celata* (Topsent, 1900). *C. insidiosa* and *C. millepunctata* differ from *C. peponaca* in possessing smaller tylostyles with globose or elliptical heads, respectively, and excavations and papillae of relatively small diameter. Hancock's descriptions of all eight of the above species (1849, 1867), for the most part based on dried specimens, are not detailed enough to permit subsequent recognition of his species. In addition, as mentioned previously, Hancock's type specimens are apparently no longer in existence.

In 1915 Annandale, working with the clionids of India, described a new species, *C. kempi*, a sponge he believed to be closely related to *C. lobata* Hancock and *C. michelini* Topsent, although it only possessed a spiculation of tylostyles. The tylostyles, 127–205 μm by 4.1–8.2 μm , are rather short and slender, bear subterminal knobs and taper to very fine points. Papillae and excavations are said to be minute.

Cliona langae, n. sp.

Diagnosis: A brown-black, zoanthid-bearing sponge that tends to overgrow the substrate completely, covering it with a thin layer of tissue. The surface is covered with small ostia interspersed with rather large, prominent oscules. The internal lobes, dull yellow in color, completely fill the galleries. Spiculation composed of long stout tylostyles, 357 μm by 13.3 μm (mean length by mean width of five specimens) and spiny spirasters, 31.3 μm by 1.6 μm .

Color. In life, the surface is brown-black, the internal lobes are dull yellow. At all depths from which it was collected, the sponge appears black to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, the surface is pale grey and the interior is colorless. Dried specimens have a pale brown surface and pale yellow interior.

Substrates. *Montastrea annularis* (Ellis & Solander), *Acropora cervicornis* (Lamarck), *Eusmilia fastigiata* (Pallas), overgrowing the surface of a colony, and dead coral (massive heads).

Depth. Collected from 15–33 m. A specimen of *C. langae* from 36 m was photographed by H.M. Reiswig.

Spiculation. 1) Numerous, long stout tylostyles (Fig. 9A). The shaft is most frequently observed to be straight. Very rarely, it is slightly curved. The diameter of the shaft constricts slightly below the head region. Maximum diameter is at the base of the spicule, and the shaft tapers very gradually from this region

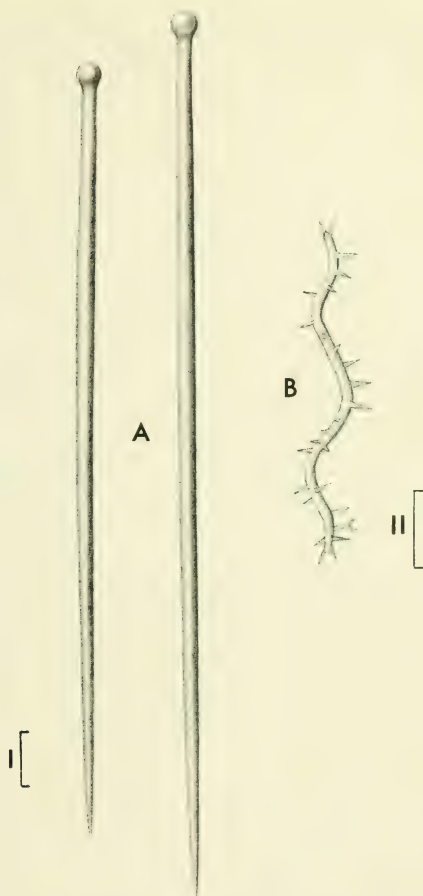


Fig. 9. Spicules of *Cliona langae* n. sp. A. Tylostyles. B. Spiraster. Scale I = 25 μm ; scale II = 5 μm .

toward the pointed end. The knob is always terminal and quite globose, with a maximum diameter of 12.2-16.8 μm . The spicules do not tend to exhibit any variety in form of the knob or curvature of the shaft. Tylostyle length: $357 \pm$

3.1 μm , 303–407 μm . Tylostyle width: $13.3 \pm 0.16 \mu\text{m}$, 9.0–15.9 μm . (2) Abundant spiny spirasters (Fig. 9B). The low, thin spines spiral around the axis of the spiraster and are rather widely spaced. They do not branch. Some spirasters have 2–3 turns; many are almost straight. All are quite slender. Spiraster length: $31.3 \pm 0.7 \mu\text{m}$, 28.3–35.0 μm . N=7 specimens. Fifty spicules in each category were measured for each specimen.

Surface. The sponge tends to overgrow the surface of its substrate completely, covering it with a thin layer of tissue. It has not been observed to enter the massive or gamma stage. *C. langae* is most frequently found inhabiting relatively small (less than one meter in diameter), flattened coral heads of species such as *Montastrea annularis* or *M. cavernosa* on the fore reef slope. The surface of the sponge is composed of ostial areas interspersed with rather large oscules, 4–6 mm in diameter when fully expanded. The sponge often appears as a cushion shaped mass of tissue completely enveloping the surface of its substrate. Most specimens of this species are observed to possess numerous, scattered individuals of the small, white, epizoic zoanthid *Parazoanthus parasiticus* (Duch. & Mich.). This zoanthid has also been observed to occur in association with *C. delitrix* and has been described in detail in the section concerning that species. Two specimens of *C. langae* were found inhabiting dead branches of *A. cervicornis*. The first specimen, from a depth of 16 meters, formed a small cushionlike patch, only 1 cm in diameter, on the surface of the coral. Oscules, fully expanded were only slightly larger than 1 mm in diameter. This sponge possessed a few zoanthids. The second specimen was collected from 33 meters and is the deepest specimen of the species collected during the course of the study. This sponge did not encrust or tend to overgrow its substrate. Instead, it had quite large, separate ostial and oscular papillae. The perforations through which the papillae protrude are circular. Diameter of ostial perforations: $3.89 \pm 0.37 \text{ mm}$, 3.46–4.07 mm. Diameter of oscular perforations: $3.94 \pm 0.39 \text{ mm}$, 3.61–4.12 mm. N=1 specimen. One specimen of this sponge, also bearing zoanthids, was found completely encrusting the top of a colony of *Eusmilia fastigiata*. This coral bears individual corallites at the ends of branches that are quite close to one another.

Excavations. The relatively large galleries are irregular in outline and are often confluent. The excavations extend from the surface of the substrate to a depth of as much as 3–4 cm within the corallum. In life, the soft, delicate tissue of the sponge completely fills the excavations and also covers the thin remnants of coral skeleton remaining between adjacent galleries. When an infected coral head is viewed in longitudinal section, it may be seen that the network of galleries forms a brown-yellow band immediately beneath the overgrown surface. The excavations of the sponge greatly weaken the structure of the coral skeleton. Diameter of the excavations: $2.31 \pm 0.09 \text{ mm}$, 2.07–2.78 mm. N=6 specimens.

Internal Structure. The tissue of the sponge is dense and contains tylostyles strewn in confusion. Tylostyles also form the framework of the oscules. Although spirasters are present in the choanosome, lining canals, they are most abundant

in the encrusting surface tissue. Two types of spherular cells are present. Small, eosinophilic, spherular cells, $6.3-8.2\ \mu\text{m}$ in diameter, are abundant and conspicuous throughout the mesohyl and choanosome. The less numerous, larger, elongated pigment cells ($15.7\ \mu\text{m}$ by $5.2\ \mu\text{m}$) bear smaller globules and are dark brown. This species possesses unicellular, symbiotic algae, $7.4-8.9\ \mu\text{m}$ in diameter, that appear pale yellow-brown in eosin and hematoxylin-stained sections. Sections stained with toluidine blue reveal a moniliform structure of the nucleus suggesting that they are zooxanthellae. These algae are quite abundant, particularly throughout the superficial layers of the sponge. The spherical choanocyte chambers are $20-24\ \mu\text{m}$ in diameter. One specimen (collected at Discovery Bay, Jamaica, on Nov. 3, 1969, from 30 m by H.M. Reiswig) contained numerous, large, ovoid eggs, $100\ \mu\text{m}$ by $72\ \mu\text{m}$, with a lightly staining nucleus ($28\ \mu\text{m}$ in diameter) and a very darkly staining nucleolus.

Holotype. YPM No. 8716. Inhabiting dead coral from 30 m, Discovery Bay, Jamaica. Collected by R. Keeley Pang, Oct. 28, 1968. Repositories of paratypical material: BMNH and SUNY-UW1. Eight specimens from the reefs of Discovery Bay and Rio Bueno, Jamaica, were studied.

Comparison With Other Species Of The Genus *Cliona*. Species of the genus *Cliona* possessing long, stout tylostyles and long, rather thin, spiny spirasters include *C. celata*, *C. viridis*, *C. subulata*, *C. caribbaea*, and *C. orientalis* Thiele (1900). Of these, *C. subulata* and *C. orientalis* were considered by Vosmaer (1933) to be insufficiently described. *C. caribbaea* and its relation to *C. viridis* are discussed above. *C. celata* and *C. viridis* both become massive, passing through a very transitory beta stage. Although *C. langae* does not appear to be close to either of these sponges, it is interesting to note that *C. viridis* from the Mediterranean also possesses symbiotic algae (Sarà and Liaci, 1964; Sarà, 1965). *C. aprica*, a new species from Jamaica, with relatively long, stout tylostyles and spiny spirasters, is described below. It differs from the present species in the degree of encrustation of the substrate, the oscular dimensions, spicular dimensions and spination of the spirasters, as well as the dimensions and form of the excavations and internal portions.

Remarks. The species name is given in honor of Dr. Judith C. Lang, who first discovered the presence of this, and several other, species of clionids on the Jamaican reefs.

***Cliona laticavicola*, n. sp.**

Diagnosis. Sponge with dull orange papillae and red-orange internal lobes, excavating very wide galleries that are completely filled with its tissue, and having a spiculation composed solely of tylostyles. Two forms occur. One, from shallow water (0–5 m), possesses scattered ostial and oscular papillae that often undergo fusion, and long, stout, slightly curved tylostyles, $349\ \mu\text{m}$ by $10.2\ \mu\text{m}$

(mean length by mean width of six specimens); the other, from deeper water (12–17 meters), possesses smaller papillae that do not tend to undergo fusion, and has shorter, thinner tylostyles, $279\text{ }\mu\text{m}$ by $7.3\text{ }\mu\text{m}$. Tylostyles of both forms most frequently bear subterminal knobs.

Two forms of this species occur on the reefs of Discovery Bay, one from shallow water and the other from deeper water. Each of the forms is described separately below.

Cliona laticavicola forma *laticavicola*

Color. In life, the papillae are orange, the internal lobes are red-orange. Very shallow specimens (1–2 meters) will appear orange to the diver whereas specimens from slightly deeper water (3–5 meters) appear orange-brown. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol the sponge is dark orange-brown. Dried specimens are pale orange-brown.

Substrates. *Diploria labyrinthiformis* (Linnaeus), *Montastrea annularis* (Ellis & Solander), *Porites porites* (Pallas), *P. astreoides* (Lesueur) encrusting old coral rock, *Acropora palmata* (Lamarck), dead coral, and coral rock.

Depths. Specimens from 0–3 m were collected and preserved. The sponge was observed to occur commonly in *A. palmata* to a depth of 5 m. Specimens from 5 m were collected and examined in the laboratory but not preserved.

Spicules. (1) Long, relatively stout tylostyles (Fig. 10), most possessing a straight shaft, some with the shaft slightly curved. The greatest diameter of the shaft is in the midregion of the spicule. The shaft tapers quite abruptly from a point approximately $15\text{ }\mu\text{m}$ above the pointed end of the spicule. The knob is most frequently observed to be subterminal with a maximum diameter of $12.2\text{--}14.0\text{ }\mu\text{m}$. The tip is very blunt and rounded. The head region of the spicule may exhibit a rather wide variety of shapes. They are as follows: (a) head elongated, somewhat spatulate, with a maximum diameter of $10.8\text{--}12.1\text{ }\mu\text{m}$, (b) head with an asymmetrically subterminal knob more developed on one side than the other, (c) knob subterminal but with the swelling set back away from the tip a distance of $5\text{--}8\text{ }\mu\text{m}$, (d) head region devoid of any swelling or differentiation from the shaft, spicule possesses a slight swelling near the central region and looks rather like a style. Spicules in this category are rare. Ditylote spicules are not numerous but a few are present in each of the above categories. Tylostyle length: $349 \pm 3.1\text{ }\mu\text{m}$, $256\text{--}404\text{ }\mu\text{m}$. Tylostyle width: $10.2 \pm 0.1\text{ }\mu\text{m}$, $6.7\text{--}12.6\text{ }\mu\text{m}$. $N=6$ specimens. Fifty spicules were measured for each specimen considered. (2) No microscleres were observed to be present.

Surface. The scattered separate ostial and oscular papillae are very numerous, and are quite large. Although they form no distinct pattern over the surface of the sponge, they often undergo fusion. The perforations through which the water enters are quite circular, those of the larger papillae are

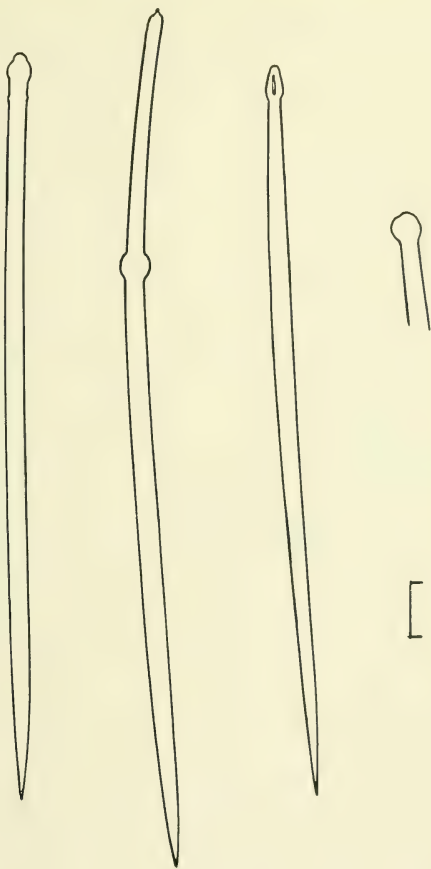


Fig. 10. Tylostyles of *Cliona laticavicola* n. sp. forma *laticavicola*. Scale = 25 μ m.

rather irregular in their outline. Even the larger, and presumably older, specimens have not been observed to overgrow the surface of their substrate. The oscules are short (approximately 3 mm in height), wide, and rounded, having their greatest diameter at the base. When fully expanded, the diameter of the oscular opening is 1 mm or less. The largest oscular papillae have excentrically

positioned oscules and also exhibit ostial areas. This is most probably due to papillary fusion. The ostial papillae are sievelike and form low mounds lying close to the surface of the substrate. Diameter of ostial perforations: 2.55 ± 0.13 mm, 2.09–3.31 mm. N=7 specimens. Diameter of oscular perforations: 2.83 ± 0.17 mm, 2.41–3.78 mm. N=7.

Excavations. Large galleries completely filled with the rather tough tissue of the sponge (Fig. 23). This species inhabits a wide variety of substrates. The shape and dimensions of its galleries are, to a certain extent, dependent upon the shape and dimensions of the substrate. One of the most common substrates, *Acropora palmata*, forms large, flattened, frondlike branches. In pieces of this coral having a thickness of approximately 1 cm, the sponge forms elongated flattened galleries that are somewhat sausagelike in their appearance. Adjacent galleries are separated by thin remnants of the substrate (1–2 mm in width). Diameter of the galleries in *A. palmata*: 16.0 ± 1.4 mm, 9–20 mm (long axis); 6.0 ± 0.89 mm, 4.4–7.9 mm (short axis). N=4 specimens. The galleries leave only 3–4 mm of the coral skeleton remaining at either surface of the coral. In the rather stout branches of colonies of *Porites porites*, the sponge forms cylindrical excavations. When an infected branch is viewed in cross section, the sponge may be seen as a mass of tissue occupying the central axis. In outline, it forms a circle with a very regular circumference. Diameter of the galleries in *P. porites*: 14.0 ± 0.09 mm, 8.3–17.2 mm. N=4 specimens. A single lobe of the sponge may extend along the axis of the coral for 2–3 cm. Subsequent lobes are interconnected by very slender (1–2 mm in diameter) stems of various lengths. When the sponge inhabits the more massive coral heads (*Diploria labyrinthiformis*, *Montastrea annularis*) or massive pieces of old coral rock, it forms very extensive galleries with an irregular or ragged outline. Diameter of the galleries in massive substrates: 4.6 ± 0.27 cm, 3.8–6.0 cm (long axis); 3.2 ± 0.17 cm, 2.2–4.8 cm (short axis). N=4 specimens. In such substrates the galleries lie rather near one of the surfaces. In all substrates the channels leading from the internal lobes of the sponge to the surface openings are quite short and wide. Length: 4.4 ± 0.15 mm, 3.8–5.7 mm. Width: 2.8 ± 0.07 mm, 1.7–3.4 mm. N=7 specimens.

Internal Structure. The tylostyles of the internal lobes are strewn in confusion. Choanocyte chambers are 21–24 μ m in diameter. Two types of spherular cells are present. Golden brown pigment cells appear capable of assuming a variety of shapes, from spherical to elongate. They are rather small, 6.3–8.9 μ m in diameter. The second type of spherular cell, localized in the choanosome, are elongated and more than twice as large as the pigment cells (14–18 μ m by 5–7 μ m). They have highly eosinophilic granules, a pale, large nucleus and prominent nucleolus.

Notes On *C. laticavicola* forma *laticavicola* From Puerto Rico. The Porifera collection of the Peabody Museum at Yale contains a specimen (YPM No. 1414B) of *C. laticavicola* forma *laticavicola* from 1–3 m of water at Cayo de los Indios, near La Parguera, Puerto Rico. The sponge, collected in 1959, by Dr. W.D. Hartman, was found inhabiting old, dead pieces of *Acropora pal-*

mata and the central axis of a living colony of *Millepora* sp. It appears to be exceptionally vigorous in the extent of its growth. This specimen closely resembles those Jamaican specimens described above in regard to spicular morphology, surface morphology, and the extent and configuration of the excavations. Measurements made on the preserved specimen reveal the following statistics: tylostyle length, $339 \pm 4.4 \mu\text{m}$ (mean \pm standard deviation), 301–363 μm (range); tylostyle width, $8.9 \pm 0.2 \mu\text{m}$, 7.3–10.6 μm (fifty spicules were measured); diameter of ostial perforations, $3.27 \pm 0.11 \text{ mm}$, 2.81–3.39 mm; diameter of oscular perforations, $3.41 \pm 0.16 \text{ mm}$, 2.99–4.00 mm; diameter of excavations, $1.8 \pm 0.1 \text{ cm}$, 1.1–2.4 cm.

Cliona laticavicola forma *parvispiculata*

Color. In life, after preservation or drying, the color is as described for *C. laticavicola* forma *laticavicola*. The sponge appears brown to the diver.

Substrates. *Acropora cervicornis* (Lamarck). The sponge has not been observed to occur in any other substrates.

Depths. Collected from 12–20 m.

Spicules. (1) Tylostyles like those of *C. laticavicola* forma *laticavicola* but shorter and somewhat thinner (Fig. 11). The spicules most frequently have subterminal heads and exhibit variations in the shape and position of the knob that are similar to those described above for *C. laticavicola* forma *laticavicola*. Tylostyle length: $274 \pm 2.8 \mu\text{m}$, 248–324 μm . Tylostyle width: $7.3 \pm 0.18 \mu\text{m}$, 5.0–9.2 μm . Fifty spicules were measured for each specimen considered. (2) No microscleres were observed.

Surface. The numerous ostial and oscular papillae are similar in their morphology to those of the shallow water form described above. They are, however, slightly smaller. Diameter of ostial perforations: $2.18 \pm 0.05 \text{ mm}$, 1.15–3.26 mm. N=4 specimens. Diameter of oscular perforations: $2.54 \pm 0.03 \text{ mm}$, 1.60–3.87 mm. N=3 specimens. The sponge does not overgrow the surface of its substrate, but papillary fusion may be observed.

Internal Structure. As described for the shallow water form of the species.

Holotype. The holotype of *C. laticavicola* is YPM No. 8720. This specimen, representative of the shallow water form of the species, was found inhabiting coral rock from 3 m. Collected by R. Keeley Pang and P.K.T. Pang, November 29, 1969, at Discovery Bay, Jamaica. Six specimens from the reefs of Discovery Bay were studied. (Paratypical material includes YPM No. 8721, representative of the deep water form. Inhabiting *A. cervicornis* from 12 m, Discovery Bay, Jamaica). Repositories of other paratypical material: BMNH and SUNY-UW1.



Fig. 11. Tylostyles of *Cliona laticavicola* n. sp. forma *parvaspiculata*. Scale = 25 μ m.

Comparison With Other Species Of The Genus *Cliona*. *C. laticavicola* may be distinguished from all other species of clionids by its exceptionally wide, cavernous galleries and spiculation composed solely of large, stout tylostyles, most frequently having asymmetrical, subterminal knobs.

Remarks. The species name is from the Latin *latus* (wide) + *cavea* (excavation) + *-colus* (inhabiting, dwelling).

***Cliona aprica*, n. sp.**

This sponge, when young, possesses numerous small, separate apertures and oscular papillae. Although older specimens exhibit

extensive papillary fusion, the sponge never completely overgrows the surface of the substrate. The internal lobes, dull yellow in life, completely fill the spherical to ellipsoidal galleries. Two forms of this species occur. One, from shallow water (0–5 m), with a spiculation composed of tylostyles, $326\text{ }\mu\text{m}$ by $8.4\text{ }\mu\text{m}$ (mean length by mean width of six specimens) and spiny spirasters, $34.1\text{ }\mu\text{m}$ by $1.9\text{ }\mu\text{m}$, has larger, stouter oscules and overgrows the substrate more extensively; the other, from deeper water (12–34 m), possesses smaller, thinner tylostyles, $286\text{ }\mu\text{m}$ by $7.9\text{ }\mu\text{m}$ and slightly smaller spirasters, $33.9\text{ }\mu\text{m}$ by $1.8\text{ }\mu\text{m}$. Each of the forms is described separately below.

Cliona aprica forma *aprica*

Color. In life, the surface is brown–black, the interior is yellow. At all depths from which it was collected, the sponge appears black to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, the surface is pale grey, the interior is colorless. Dried specimens have a very pale brown surface and pale yellow interior.

Substrates. *Acropora palmata* (Lamarck), *Porites astreoides* (Lesueur), dead coral, and coral rock.

Depths. Collected from 0–5 m.

Spicules. (1) Abundant tylostyles (Fig. 12A) with a relatively stout shaft that is most frequently slightly curved but is sometimes straight. The shaft has its greatest diameter near the midregion and tapers very gradually toward the pointed end. The knob, with a maximum diameter of $9.3\text{--}11.4\text{ }\mu\text{m}$, is always terminal. It is globose to elliptical; the globose forms predominate. Frequently there is a secondary annular swelling behind the head region. This swelling may occur immediately behind the knob or may be some $5\text{--}10\text{ }\mu\text{m}$ behind it. The spicules do not exhibit great variety in their form. Tylostyle length: $326 \pm 3.1\text{ }\mu\text{m}$, $284\text{--}356\text{ }\mu\text{m}$. $N=6$ specimens. Tylostyle width: $8.4 \pm 0.16\text{ }\mu\text{m}$, $7.8\text{--}10.6\text{ }\mu\text{m}$. $N=6$ specimens. (2) Spirasters (Fig. 12B) are common but not abundant. They are located primarily within the surface tissue and may be overlooked in spicule preparations made only with tissue from the galleries. The spirasters may be spiral with 2–3 turns, C-shaped or almost straight. All possess spines, $1\text{--}2\text{ }\mu\text{m}$ in length, along the axis and at either end of the axis. Although the spines are always observed to be restricted to the convex side of the axis, their form, number and arrangement are variable. Length of spiral spirasters: $34.1 \pm 1.4\text{ }\mu\text{m}$, $29.2\text{--}39.8\text{ }\mu\text{m}$. Width of spiral spirasters: $1.9 \pm 0.07\text{ }\mu\text{m}$, $1.4\text{--}2.5\text{ }\mu\text{m}$. $N=7$ specimens. Length of straight spirasters: $17.9 \pm 0.18\text{ }\mu\text{m}$, $16.1\text{--}19.4\text{ }\mu\text{m}$. Width of straight spirasters: $7.4 \pm 0.10\text{ }\mu\text{m}$, $6.9\text{--}7.8\text{ }\mu\text{m}$. Length of C-shaped spirasters: $14.3 \pm 0.17\text{ }\mu\text{m}$, $12.2\text{--}15.9\text{ }\mu\text{m}$. Width of C-shaped spirasters: $2.6 \pm 0.05\text{ }\mu\text{m}$, $2.0\text{--}3.7\text{ }\mu\text{m}$. Fifty spicules from each of the two categories were measured for each specimen considered.

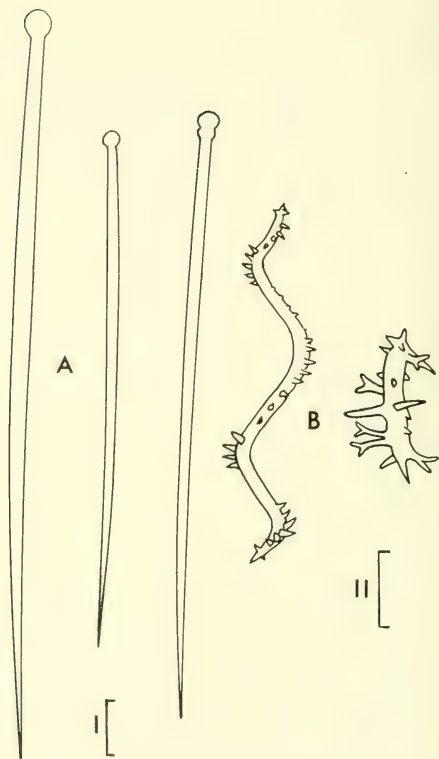


Fig. 12. Spicules of *Cliona aprica* n. sp. forma *aprica*. A. Tylostyles. B. Spirasters. Scale I (A) = 25 μ m; scale II (B) = 5 μ m.

Surface. The sponge always tends to overgrow the surface of its substrate. Very young specimens have numerous, separate ostial and oscular papillae that protrude through nearly circular perforations in the substrate. The papillae are irregularly distributed over the surface, forming no distinct pattern. Oscules (Fig. 21) are small, stout and have their greatest diameter at the base. Viewed from above with a dissecting microscope, the ostial papillae present a reticulated pattern. Ostial papillae are raised up above the surface of the substrate. The numerous ~~ostia~~ ~~are~~ ~~confined~~ ~~to~~ ~~the~~ ~~top~~ ~~surface~~ ~~of~~ ~~the~~ ~~papillae~~ ~~and~~ ~~are~~ ~~approximately~~ ~~15–20~~ ~~μ m~~ ~~in~~ ~~diameter~~. Fusion of the papillae is quite common, even in young

specimens. As the sponge begins to overgrow the substrate, the oscules become surrounded by ostial areas until almost all the papillae are confluent. Tiny ($7-10\ \mu\text{m}$ in diameter) chips of calcium carbonate may often be seen surrounding the base of the oscules. Almost all of the specimens of *C. aprica* forma *aprica* observed or collected encrusted a large portion of their substrate with a thin layer of tissue. Diameter of circular ostial perforations: $0.52 \pm 0.06\ \text{mm}$, $0.30-0.64\ \text{mm}$, $N=4$ specimens. Diameter of elliptical perforations of ostial papillae and of compound papillae (ostial and oscular): $1.05 \pm 0.07\ \text{mm}$, $0.80-1.84\ \text{mm}$ (short diameter); $1.67 \pm 0.09\ \text{mm}$, $0.96-3.20\ \text{mm}$ (long diameter). $N=6$ specimens.

Excavations. The relatively small spherical to ellipsoidal galleries are quite irregular in outline and very frequently are confluent. The soft tissue of the sponge completely fills, and is always confined to, the galleries. In substrates such as *Acropora palmata* the excavations lie close to the overgrown surface and only extend approximately $8-9\ \text{mm}$ down into the skeleton of the coral. Channels leading from the galleries to the surface papillae are very short ($1-2\ \text{mm}$) and relatively wide ($2-3\ \text{mm}$ in diameter). Diameter of galleries: $1.20 \pm 0.09\ \text{mm}$, $1.08-1.89\ \text{mm}$. $N=6$ specimens.

Internal Structures. The tylostyles are abundant in the surface layers, with the pointed ends directed outward. Sections through the ostial papillae reveal a band of parallel tylostyles comprising the framework of the papillae. Spirasters, most abundant in the surface layers at the base of papillae, are also present in the choanosome. The tylostyles of the internal lobes are strewn in confusion. Two types of spherular cells are present. The highly eosinophilic spherular cells have a diameter of $8.4-10.5\ \mu\text{m}$. The brown pigment cells are larger, with a diameter of $11.7-14.0\ \mu\text{m}$, but have smaller globules. The species possesses unicellular, symbiotic algae ($8.1-10.0\ \mu\text{m}$). Spherical choanocyte chambers are $18-22\ \mu\text{m}$ in diameter.

Cliona aprica forma *profunda*

Color. As for *C. aprica* forma *aprica*. The surface, in life, is slightly paler, sometimes almost grey.

Substrates. *Acropora cervicornis* (Lamarck), *Solenastrea bournonii* Milne Edwards & Haime, *Agaricia agaricites* (Linnaeus) forma *agaricites*, *A. agaricites* forma *purpurea*, *Montastrea annularis* (Ellis & Solander), *M. cavernosa* (Linnaeus), *Porites furcata* (Lamarck), *Lucina pensylvanica* (bivalve), dead coral and coral rock.

Spicules. (1) Abundant tylostyles (Fig. 13A) resembling those of *Cliona aprica* forma *aprica* in their form, but with the shaft slender rather than stout and considerably shorter. The last one-third of the shaft of a few tylostyles is rather sharply bent. Tylostyle length: $286 \pm 2.3\ \mu\text{m}$, $276-297\ \mu\text{m}$. Tylostyle width: $7.9 \pm 0.11\ \mu\text{m}$, $7.7-8.2\ \mu\text{m}$. $N=9$ specimens. (2) Spirasters (Fig. 13B) have the same

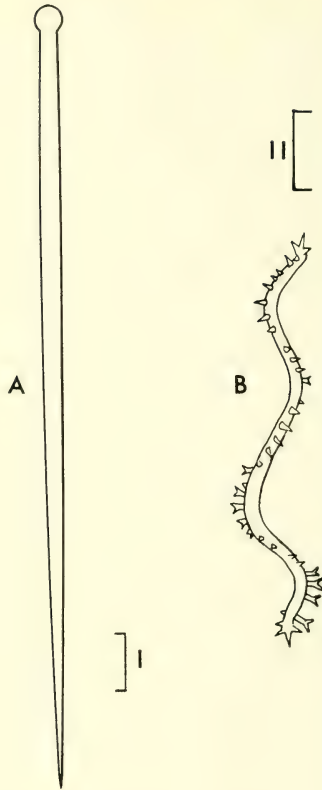


Fig. 13. Spicules of *Cliona aprica* n. sp. forma *profunda*. A. Tylostyle. B. Spiraster. Scale I = 20 μ m; scale II = 5 μ m.

location and form as those described for *C. aprica* forma *aprica*. They are slightly smaller. Fifty spicules from each of the two categories were measured for each specimen considered.

Surface. As described for the shallow water form, this sponge always tends to overgrow the surface of the substrate. The progression from separate ostial and acicular papillae through papillary fusion to the encrusting of the substrate is

also seen in this form. However, the encrusting of the surface has not been observed to proceed as far as that of the shallow water form. The dimensions of the papillary perforations are similar to, but slightly smaller than, those given for *C. aprica* forma *aprica*. When fully expanded, the oscules are short cylinders of uniform diameter. They are slightly smaller than the oscules of *C. aprica* forma *aprica*.

Excavations. As described for the shallow water form the galleries are irregular in outline and often are confluent. When the sponge inhabits massive substrates (*M. annularis*, *M. cavernosa*, *S. hyades*), its excavations are confined to the superficial portions of the corallum. However, in the rather slender branches of *A. cervicornis*, *C. aprica* forma *profunda* may produce a network of galleries extending from one surface of the branch to the opposite one.

Internal Structure. As described for *C. aprica* forma *aprica*. However, both the eosinophilic spherular cells and the algae are less numerous in the deep water form.

Holotype. The holotype of *C. aprica* is YPM No. 8722. This specimen, representative of the shallow-water form of the species, was found inhabiting *A. palmata* from 2 m. Discovery Bay, Jamaica. Collected by R. Keeley, March 28, 1969. Six specimens from the reefs of Discovery Bay were studied. (Paratypical material includes YPM No. 8723, representative of the deep water form of this species. Inhabiting *A. cervicornis* from 15 m. Discovery Bay, Jamaica.) Repositories of other paratypical material are: BMNH and SUNY-UW1.

Comparison With Other Species Of The Genus *Cliona*. *C. aprica* is compared with *C. langae* in the discussion of the latter species.

Family SPIRASTRELLIDAE

Anthosigmella varians (Duch. & Mich.) de Laubenfels

Thalysias varians Duchassaing and Michelotti, 1864, p. 86.

Anthosigmella varians, de Laubenfels, 1936a, p. 143.

(non) *Anthosigmella varians*, Wells, Wells and Gray, 1960, p. 55.

Suberites tuberculosus Schmidt, 1870, p. 46.

Suberites coronarius Carter, 1882, p. 352.

(non) *Suberites coronarius*, Carter, 1897, p. 74.

Spirastrella coronaria, Topsent, 1894, p. 26.

Anthosigmella coronarius, Topsent, 1918, p. 557.

(non) *Cliona coronaria*, Dendy, 1916, p. 132.

Papillina arcuata Topsent, 1889, p. 35.

Color. In life, the surface is brownish tan, the interior is dull yellow. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, the sponge is beige. Dried specimens are pale brown.

Substrates. *Acropora cervicornis* (Lamarck) and dead coral (massive heads).

Depths. Collected from 20–41 m.

Material. Four specimens from the reefs of Discovery Bay, Jamaica, were studied.

Spicules. (1) Abundant, long, rather slender tylostyles (Fig. 14A), tapering gradually toward the pointed end. Most have a slightly curved shaft, a few are straight. Occasionally the shaft may be arched or bent at the midregion. There is considerable variation in the shape of the head region: (a) head elongated, well developed with a constriction in the neck region; (b) head elliptical with small annular swelling immediately behind it; (c) knob subterminal, tip rounded and blunt; (d) development of head much reduced; spicules are stylelike. These are rare. Tylostyle length: $423 \pm 2.9 \mu\text{m}$, 271–465 μm . Tylostyle width: $8.7 \pm 0.12 \mu\text{m}$, 7.9–10.4 μm . N=4 specimens. (2) Abundant anthosigmas (Fig. 14B); most are arched and C-shaped, a few are almost straight. There are prominent, knoblike spines on the convex side and at each extremity. The knobs at the extremities are frequently branched and those along the axis may also be branched. Anthosigma length: $19.4 \pm 0.14 \mu\text{m}$, 15.4–24.9 μm . Anthosigma width: 2.2 ± 0.17 , 1.9–2.5 μm . N=4 specimens. Fifty spicules in each category were measured for each specimen considered.

Surface. Sponge completely encrusting the surface of the substrate with a thick layer of rather rubbery tissue. Ostia are minute. Oscules are quite small and inconspicuous, approximately 2–3 mm in diameter.

Interior. Internal portions of sponge inhabit rather large hollows or cavities in the upper portion of the corallum of dead coral. The cavities resemble the excavations produced by *C. aprica*. Evidence is inconclusive as to whether *A. varians* is capable of producing the cavities through its own activity or whether it merely infiltrates spaces already present within the coral skeleton. Diameter of cavities: $2.9 \pm 0.07 \text{ mm}$, 2.2–3.8 mm. N=3 specimens.

Internal Structure. As described by Hechtel (1965, p. 56). Anthosigmas are most abundant in the interior of the sponge, particularly in the choanosome where they are found lining canals. Symbiotic algae, 8.9–10.3 μm in diameter, are present but not abundant.

Taxonomic Discussion. Despite the presence of highly distinctive microscleres, the taxonomic history of *A. varians* has been quite complex. The original description (as *Thalassia varians*) by Duchassaing and Michelotti in 1864, although insufficient, emphasized the great variation in shape that this species may undergo. The variation of the sponge was neither described nor figured. Schmidt

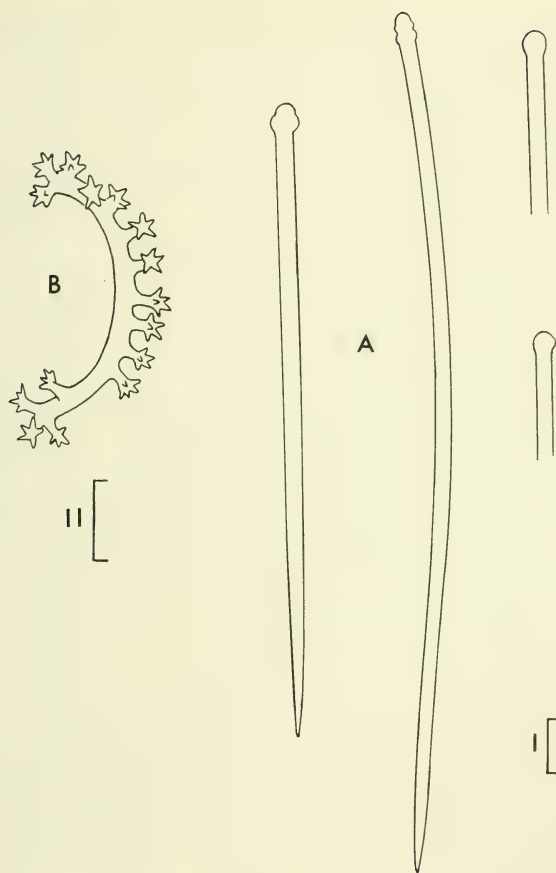


Fig. 14. Spicules of *Anthosigmella varians* (Duch. & Mich.). A. Tylostyles. B. Anthosigma. Scale I (A) = 25 μ m; scale II (B) = 5 μ m.

(1870) believed that he was dealing with a new species, *Suberites tuberculosus*, that took many forms: encrusting, massive or branching. The presence of spirasters was not mentioned. Carter (1882) proposed the new species, *Suberites coronarius*, for a West Indian sponge with peculiar spirasters. In 1889 Topsent

described *Papillina arcuata*, with arched spirasters bearing knoblike, branched spines, from the Campeche Bank. Then, in 1894, Topsent placed *P. arcuata* in synonymy with *Suberites coronarius* Carter and transferred Carter's species to the genus *Spirastrella*. In 1913 he established a new genus, *Anthosigmella*, for sponges with the distinctive anthosigmas as microscleres, and transferred *Spirastrella coronaria* (Carter) Topsent to that genus. Topsent (1920) later re-examined Schmidt's type specimen and, after finding anthosigmas, placed it in synonymy with *A. coronarius*. However, in 1936, de Laubenfels transferred *Thalysias varians* Duch. & Mich. to the genus *Anthosigmella* and placed Carter's species in synonymy with it.

Geographical Distribution. West Indies: Jamaica, Carter, 1882, p. 352 (as *Suberites coronarius*), Hechtel, 1965, p. 55; Bahamas, Carter, 1882, p. 352 (as *Suberites coronarius*), de Laubenfels, 1949, p. 19; Honduras, Carter, 1882, p. 352 (as *Suberites coronarius*); Lesser Antilles, Duchassaing and Michelotti, 1864, p. 86 (as *Thalysias varians* from Guadeloupe, St. Barthelemy, St. Thomas and Tortole). Florida: Schmidt, 1870, p. 46 (as *Suberites tuberculosus*). Gulf of Mexico: Campeche Bank, Topsent, 1889, p. 35 (as *Papillina arcuata*); Florida Gulf coast, de Laubenfels, 1953, p. 539, Little, 1963, p. 55.

A. varians, under a variety of names, has often been reported from the West Indies, Florida and the Gulf of Mexico. It is apparently endemic to this region.

Discussion: The specimens of *A. varians* from Discovery Bay were all of the encrusting form with the internal portions of the sponge inhabiting cavities within corals. None of the previous reports of this species have mentioned this habit. De Laubenfels wrote of *A. varians*, "This common West Indian sponge is strikingly marked by its occurrence in coral sand with a buried substratum from which digitate processes arise" (p. 203).

However, Carter (1887) in a record of the presence of his species *Suberites coronarius* from the Mergui Archipelago, stated that the lower portion of the sponge is "mingled with a layer of coral which has been cancelled by the excavating habit of the sponge" (p. 74). Thiele (1900), who believed that the Mergui sponge was not the same as the West Indian sponge, redescribed the former as *Cliona orientalis* from specimens from Ternate, Indonesia. Annandale (1915) re-examined a portion of Carter's material from Mergui and concluded that Thiele had been correct in his assumptions. Dendy (1916) reported *Suberites coronarius* dwelling in cavities in corals. Based on this, he transferred the species to the genus *Cliona*. Although the specimens reported by Carter (1887) and Dendy (1916) are most probably clionids and not *A. varians*, it should be noted that *A. varians* does occupy an extensive network of cavities in corals.

(Order and Family Uncertain)

Alectona jamaicensis, n. sp.

Diagnosis: sponge with numerous, small, separate, pale-yellow ostial and oscular papillae and relatively large spherical to ellipsoidal galleries. Spiculation

composed of the following three categories, the first two exhibiting a wide range of variation in form: (1) stout diactinal spicules, $215\ \mu\text{m}$ by $10.8\ \mu\text{m}$, (mean length by mean width of one specimen), covered with rounded tubercles that may be either low or prominent but are never branched or spined; (2) thin, smaller diactinal spicules, $203\ \mu\text{m}$ by $7.9\ \mu\text{m}$; (3) amphiasters, $59\ \mu\text{m}$ by $2.2\ \mu\text{m}$, bearing a whorl of 5–6 tylote rays near each extremity.

Color. In life, pale yellow. Underwater, the sponge appears to be almost colorless to the diver. After fixation in 10% neutralized formalin and transfer to 70% ethyl alcohol, it is completely colorless.

Substrate. *Porites furcata* Lamarck.

Depth. Collected from 14 m. Only one specimen was collected during the course of the present study.

Spicules. The spiculation of the genus *Alectona* is highly distinctive. (1) Relatively few, stout diactinal spicules (Fig. 15B) of moderate length, curved or rather sharply bent in the midregion of the axis, and exhibiting a wide range of variation in their forms. Some are recurved at one end; some form a V with unequal arms. The diameter of the diactinal spicules is slightly greater in the central region than at either end. The spicules may either taper uniformly or possess a swelling or protuberance along the convex side of the axis, often near the center. The extremities are obtuse rather than pointed. The spicules are covered with rounded tubercles, apparently not arranged in any distinct pattern. The tubercles of an individual spicule may be low (less than $1\ \mu\text{m}$ in height) or quite prominent ($3\text{--}4\ \mu\text{m}$ in height), numerous or rather sparsely distributed, but the rounded extremities of the spicule always bear many low tubercles over their surface. The tubercles are never branched or spined. These spicules, all quite unusual in their appearance, are of a type not seen elsewhere within the Hadromerida. Length: $215 \pm 2.4\ \mu\text{m}$, $186\text{--}237\ \mu\text{m}$. Width: $10.8 \pm 1.2\ \mu\text{m}$, $9.6\text{--}12.3\ \mu\text{m}$. Twenty-five spicules were measured in this category. (2) Numerous thinner, slightly smaller diactinal spicules (Fig. 15A), usually smooth but sometimes bearing scattered flattened tubercles. Shaft tapers from the midregion to pointed extremities at either end. These spicules, as those described above, exhibit a wide range of forms. (a) The axis may be bent rather sharply at the center and possess a swelling in this region, on the convex side giving the spicule a winged appearance. (b) The axis may be recurved at one end. (c) The central swelling may appear as a knot or twist in the spicule. (d) The axis may be nearly straight and bear a spherical swelling at its center. Length: $203 \pm 1.7\ \mu\text{m}$, $186\text{--}287\ \mu\text{m}$. Width: $7.9 \pm 1.2\ \mu\text{m}$, $6.1\text{--}8.5\ \mu\text{m}$. Fifty spicules were measured in this category. The swelling or protuberance is reported to be the remnant of a third ray (Top-sent, 1900). See Discussion. Some spicules of the present specimen possess a rudimentary second ray, giving them a clublike or tylostylelike appearance. Length: $112 \pm 1.1\ \mu\text{m}$, $97\text{--}144\ \mu\text{m}$. Twenty-five spicules were measured in this category. (3) Abundant amphiasters (Fig. 15C) of rather precisely determined form and a wide range of lengths. The axis is of a uniform diameter, smooth except for its pointed, microspined extremities. Near each extremity is a whorl

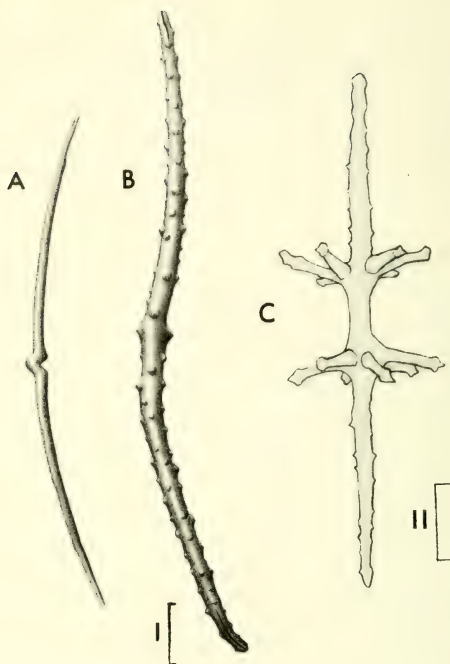


Fig. 15. Spicules of *Alectona jamaicensis* n. sp. A. Thin diactinal spicule. B. Thick diactinal spicule. C. Amphiaser. Scale I (A,B) = 25 μ m; scale II (C) = 5 μ m.

of rays, usually 5-6 in number, projecting outward from the axis, each ray bearing small spines terminally. Some rays have a slightly greater diameter at their most distal, microspined end. Length: $59 \pm 1.4 \mu$ m, 31-74 μ m. Width: $2.2 \pm 0.08 \mu$ m, 1.4-4.3 μ m. Fifty spicules were measured in this category.

Surface. Ostial and oscular papillae are separate, rather small, and low, lying close to the surface of the substrate. Fusion of the ostial papillae was not observed. The perforations through which the ostial and oscular papillae protrude are circular in outline. This specimen exhibited no tendency to overgrow the substrate. Ostial papillae are sievelike in appearance, bearing numerous small oroga. The oscules are shaped like truncated cones. Diameter of the ostial perforations: 0.51 ± 0.06 mm, 0.39-0.72 mm. N=8 measurements. Diameter of the oscular perforations: 0.54 ± 0.08 mm, 0.41-0.83 mm. N=6 measurements.

Excavations. Relatively large galleries, roughly spherical to ellipsoidal in their outline. Subsequent lobes are interconnected by cylindrical stems approximately 2 mm in diameter. Diameter of the galleries: 6.2 mm (mean), 5.8–7.9 mm (range). Three galleries were measured. The single specimen collected was found inhabiting the dead, encrusted basal portion of a relatively stout branch of *Porites furcata* (diameter: 1.2 cm). In terms of the quantity of substrate removed by the sponge, *A. jamaicensis* is a rather destructive species of boring sponge. See Discussion. The galleries are completely filled with masses of the soft sponge tissue. The internal lobes of the sponge communicate with the surface papillae through short, quite narrow channels. Diameter of the channels: 0.42 mm, 0.37–0.51 mm. Length of the channels: 3.2 mm, 2.8–3.9 mm. N=7 measurements.

Holotype. YPM No. 8718. Discovery Bay, Jamaica. Inhabiting *Porites furcata*, from 14 m. Collected by R. Keeley Pang, Nov. 10, 1969.

Taxonomic History Of The Genus *Alectona*. The genus *Alectona* (from *Alecto*, one of the furies, Carter, 1879c, p. 494) was established by Carter in 1879 for excavating sponges possessing the following spiculation: "Skeleton-spicule acerate, abruptly curved or bent in the center, tubercled throughout. Flesh-spicule spindle-like, consisting of a straight shaft, pointed at the extremities and encircled by two rings of tubercles equidistant from each other and from the ends of the shaft respectively." The genus includes: *A. wallichii* Carter, 1874, p. 252; *A. millari* Carter, 1879c, p. 494; *A. higgini* Carter, 1880, p. 58; and *A. primitiva* Topsent, 1933, p. 554. *A. wallichii* was originally described as *Gummina Wallichii*. The description was based on an isolated spicule found in an arenaceous deposit from the Agulhas Shoal, Cape of Good Hope. This spicule, according to Carter, resembled very closely an isolated spicule figured by Bowerbank (1864, p. 270, pl. xi, fig. 244) and described as having been repeatedly found in the matter obtained by washing the roots of *Oculina rosea* (*Stylaster sanguineus fide* Carter, 1879b, p. 353). In 1879 Carter redescribed *G. Wallichii* from two deep water specimens from the collection of the British Museum (Natural History). Due to an error in editing, it appeared as *Corticium Wallichii* (1879b, p. 353). Later on in the same year, the description of the new, closely allied species, *A. millari*, led Carter (1879c, p. 496) to transfer *G. wallichii* to the new genus *Alectona* and to consider it as an excavating sponge. *A. millari* has received no names in synonymy. Carter (1879c) suggested that it might be a variety of *A. wallichii* but subsequent investigators have considered it as a separate species. *A. higgini* was found excavating melobesian nodules in the Gulf of Manaar. Its flesh spicules or amphiasters are quite similar to those of *A. wallichii* and *A. millari*. However, it also possesses two other distinctive categories of spicules: (1) rather stout diactinal spicules with rounded extremities and "a number of annular depressions and inflations, the latter of which are microspined" and (2) "fine hair-like acerate" spicules "tending toward the form of a tricurvate" (Carter, 1880, p. 58). De Laubenfels (1936) believed that

this species was not of the genus *Alectona* and, perhaps, not even a sponge. He would establish the new genus *Delectona* for it. Earlier, Topsent (1891) had, however, noted the similarities between the spiculation of *A. higgini* and *Dotona pulchella* Carter, 1880, p. 57 (also originally described from melobesian nodules of the Gulf of Manaar) and suggested that the latter species might well be transferred to the genus *Alectona* or that if the genus *Dotona* were to be conserved *A. higgini* should become *Dotona higgini*.

Geographical Distribution Of The Genus *Alectona*. I. *Alectona millari*. Atlantic: between the North of Scotland and the Faroe Islands, Carter, 1879c, p. 494; coast of Norway, Topsent, 1900, p. 27; Azores, Topsent, 1900, p. 25. Mediterranean: Banyuls, Topsent, 1900, p. 25; Gulf of Naples, Sarà, 1959, p. 10, Russ and Rützler, 1959, p. 767 (as *Alectona* sp.), Rützler, 1966, p. 313. Red Sea: coast of Sudan, Topsent, 1920, p. 555. II. *Alectona wallichii*. Indian Ocean: Agulhas Shoal, Cape of Good Hope, Carter, 1874, p. 252 (as *Gummina wallichii*, from an isolated spicule); Seychelles, Carter, 1879b, p. 353 (as *Corticium wallichii*). "South Seas": Carter, 1879b, p. 353 (as *Corticium wallichii*). III. *Alectona higgini*. Indian Ocean: Gulf of Manaar, Carter, 1880, p. 58. IV. *Alectona primitiva*. Indian Ocean: coast of South Australia, Topsent, 1933, p. 555.

Comparison With Other Species Of The Genus *Alectona* And Discussion. The present species is very close to Topsent's specimens of *A. millari*, particularly that from the Mediterranean at Banyuls. It was recognized by Topsent (1933) that the specimens he had described as *A. millari* in his 1900 monograph actually differed somewhat in spicule morphology and dimensions from the type described by Carter in 1879. Unfortunately, since Carter's and Topsent's specimens were obtained from dredgings, little is known of the surface morphology of this species in life.

Until recently *A. millari* was known only as a deep-water species (from depths of 450 m or more). Volz (1939) did not find *A. millari* at Rovigno, and regarded it as being solely from deep water (p. 72). However, Sarà (1959) mentioned the presence of *A. millari* in the shallow waters of the Grotto of Gaiola (Gulf of Naples, Tyrrhenian Sea) co-occurring with *Cliona copiosa* Sarà, *C. celata*, *C. viridis*, and *Clothosa hancocki* (Schmidt) Topsent. Russ and Rützler (1959), also working in the Gulf of Naples, recorded the presence of several specimens of a yellow-white boring sponge, *Alectona* sp. In the report of a subsequent study of that area, Rützler (1966) stated that the specimens referred to as *Alectona* sp. by Russ and Rützler (1959) belong to *A. millari*. He found additional specimens boring in the dead bases of *Petrobiona massiliana* Vacelet and Sarà (Order Pharetronida, Family Murrayonidae). Unfortunately, neither Sarà nor Rützler provided a description or figures of their specimens of *A. millari*. It is interesting to note that all the shallow-water Mediterranean specimens of this sponge were taken from shaded localities or underwater caves.

Bored spicules, presumed to belong to *A. millari*, were found by Sarà (1959) in the sponges *Topsentia contorta* Sarà and *Haliclona viscosa* Sarà, from the

shallow waters of the Adriatic. Rützler (1965) also reported the presence of isolated spicules of *A. millari* in the sponge *Terpios fugax* Duch. & Mich. collected from a depth of one meter in the North Adriatic. Neither of these two reports included figures of the spicules. However, Rützler described two categories of spicules from his specimens: robust diactinal spicules bearing tubercles, 120–220 μm in length; and amphiasters with tylote rays, 15–18 μm in length. It appears impossible at this time to judge whether these investigators were dealing with *A. millari* as originally described by Carter, *A. millari sensu* Topsent (1900), the form found in the shallow waters (14 meters) of Jamaica, or with something rather different from all three of the above.

Previous collections of boring sponges from the Discovery Bay reefs, made by the late Prof. T.F. Goreau and E. A. Graham in 1962 (deposited in the Peabody Museum of Natural History, Yale University) and by Dr. J.C. Lang in 1966–67 did not reveal the presence of this species of *Alectona*. Only one specimen was observed during the course of the present study. It is most regrettable that other Jamaican or, indeed, West Indian specimens are not available for comparison.

Topsent noted irregularities in the spiny diactinal spicules of his specimen from Banyuls; he considered these to be individual teratological variations. However, much the same irregularities in form were seen in the spicules of the Jamaican specimen. Topsent did not consider the smooth, smaller diactinal spicules as belonging to a separate category. He stated that they are merely poorly developed forms of the larger, stouter diactinal spicules and noted that in both of these kinds of spicules the axial canal turns outward the swelling or protuberance. He took this to mean that these spicules are derived from a three-rayed form and that the swelling is the vestige of this third ray. Indeed, Carter (1879), who also noted the turning of the axial canal, figured and described three-, four- and five-rayed spicules. These spicules have not been reported from subsequent specimens of *A. millari* and have not been found in the Jamaican specimen. A second category of spicules found only by Carter is composed of spicules that are "acerate undulating, almost immeasurably fine, hair-like, with an enlargement in the centre barrel-shaped, inflated in the middle and at the ends respectively" (p. 495). These were not figured.

The diactinal spicules, figured and described by Carter (1879) are considerably stouter (28 μm) than those from the Jamaican specimen (9.6–12.3 μm , range). The tubercles, according to both Carter and Topsent are conical and may be branched at the extremities or may bear spines. Due to the differences in the classes of spicules present, their morphology and dimensions and to the vast differences in habitats (the very deep, cold waters of the North Atlantic as opposed to the shallow, warm waters of Jamaica), the present specimen is placed in the new species, *A. jamaicensis*.

Order HAPLOSCLERIDA

Family ADOCHIDAE

Siphonodictyon brevitubulatum, n. sp.

Diagnosis. Sponge forming a single large, spherical excavation completely filled with soft, pale-yellow, mucus-covered tissue. Lemon yellow ostial and oscular papillae are separate. The hill-like ostial papillae, composed solely of a network of numerous small ostia, are confluent in some specimens. Spiculation of smooth, rather abruptly pointed oxeas, $134\ \mu\text{m}$ by $8.0\ \mu\text{m}$ (mean length by mean width of four specimens).

Color. In life, papillae are lemon yellow; the mass of sponge within the excavation is pale, dull yellow. Underwater, the sponge appears yellow to the diver. After fixation on 10% neutralized formalin and transfer to 70% ethyl alcohol the papillae are pale yellow, and the internal portions are drab yellow-tan.

Substrates. *Porites furcata* Lamarck, *Solenastrea bournonii* Milne Edwards & Haime, *Montastrea annularis* (Ellis & Solander), *M. cavernosa* (Linnaeus), and *Acropora cervicornis* (Lamarck).

Depths. Collected from 5–32 m.

Spicules. (1) The abundant, smooth oxeas (Fig. 16) are relatively stout. They may be curved, sharply bent at the midpoint of the axis, or almost straight. The oxeas do not taper but are rather abruptly pointed. Neither styles nor strongyles have been observed. There is not great variety in the shape of the spicules or in the curvature or termination of the axis. Oxea length: $134 \pm 2.7\ \mu\text{m}$, 119–148 μm . Oxea width: $8.0 \pm 0.2\ \mu\text{m}$, 6.9–9.1 μm . N=4 specimens. Fifty spicules were measured for each specimen considered. (2) No other categories of spicules were observed to be present.

Surface. The sponge does not tend to overgrow the substrate. Ocular and ostial papillae (Fig. 24) are separate and relatively few in number. Oscules, protruding through circular perforations in the substrate, have not been observed to be surrounded by ostial areas. The oscules are cylindrical and rather prominent (7–9 mm in height) in comparison to those of most clionids. The perforations through which the ostial papillae protrude are elliptical. In some specimens ostial papillae are discrete and widely separated, while in others several papillae are confluent. These hill-like papillae, comparable in height to the oscules, are composed solely of a network of numerous small ostia. Diameter of oscular perforations: $3.11 \pm 0.14\ \text{mm}$, 1.98–3.72 mm. N=4 specimens. Diameter of ostial papillae: $1.71 \pm 0.25\ \text{mm}$, 0.98–2.04 mm (short axis); $2.03 \pm 0.31\ \text{mm}$, 1.62–2.79 mm (long axis). N=4 specimens. Confluent ostial papillae are approximately 7–8 mm by 2 mm (long axis by short axis).



Fig. 16. Oxeas of *Siphonodictyon brevitubulatum* n. sp. Scale = 20 μ m.

Excavations. The activity of the sponge produces a single, large spherical excavation completely filled with the soft, mucus-covered tissue of the sponge. In massive substrates (*S. bournonii*, *M. annularis* and *M. cavernosa*) the excavation may attain a diameter of 4–5 cm. The diameter of the excavations in branching substrates (*P. porites* and *A. cervicornis*) is considerably less, 1–2 cm. The tunnels or channels leading from the excavated cavity in the substrate to the surface openings are narrow and elongated. Channel length in massive substrates: 8.1 ± 0.1 mm, 7.2–9.8 mm. N=4 specimens. Channel length in branching substrates: 4.2 mm, 3.8–5.9 mm (two specimens). Since *S. brevitubulatum* most frequently inhabits very massive coral heads, it is difficult to bring intact specimens of this species to the laboratory for study. However, when the specimen infecting *A. cervicornis* was examined in the laboratory, it was ob-

served actively expelling tiny calcium carbonate chips through the excurrent openings.

Holotype. YPM No. 8717. Inhabiting *Montastrea annularis* at 15 meters, Discovery Bay, Jamaica. Collected by R. Keeley, Oct. 16, 1968. Repositories of paratypical material: BMNH and SUNY-UWI. Seven specimens from the reefs of Discovery Bay, Jamaica, were studied.

Comparison With Other Species Of The Genus *Siphonodictyon*. The genus *Siphonodictyon*, closely related to the genus *Phloeodictyon* Carter, was established by Bergquist (1965) for mucus-producing sponges of cryptic habit, lacking spongin and a barklike dermal region, and possessing a dermal skeleton composed of brushes of oxeas. The type species of the genus, *Siphonodictyon mucosum* Bergquist, may be distinguished from the present species by its color (black in life), the brittle texture and length of the tubes (2.0–7.4 cm) terminating in oscules or sieve areas, as well as the dimensions of the oxeas (194–212 μm by 8.5–11.5 μm). Bergquist's species is from 3–20 ft. in the Palau Islands. Rützler (1971) has described two new species of the genus *Siphonodictyon* (*S. cachacrouense* and *S. coralliphagum*) from the West Indies. He distinguished four forms of *S. coralliphagum*: forma *typica*, forma *obruta*, forma *tubulosa* and forma *incrustans*. Of these, *S. coralliphagum* forma *tubulosa* from Scotts Head Bay, Dominica, W. I., is closest to *S. brevitubulatum*. However, *S. coralliphagum* forma *tubulosa* forms dense clusters of ostial and oscular tubules with the oscular tubules attaining a height of more than twice that of the ostial tubules. Concerning the oxeas, Rützler stated that "the tips are rather blunt to mammiform, usually smooth, sometimes rough to stepped. Some styles and strongyles occur" (p. 9, and fig. 7). In addition, the oxeas, which are said to occur in two size categories, are longer but thinner than those of the present species. The spicular dimension of Rützler's USNM #24101 (specimen representative of the form), based on 100 measurements, are: 156.0–180.8 by 5.0–7.1 μm (large oxeas) and 121.6–174.4 by 1.3–4.0 μm (small oxeas).

Remarks. The species name is a compound of the Latin adjectives *brevis* (short) and *tubulatus* (tubular), for the distinctive short oscular tubes of the Jamaican specimens.

IV. Key to the Excavating Sponges Described from Discovery Bay, Jamaica

- | | |
|--|----|
| 1. Articulation including tylostyles | 2 |
| 2. Articulation not including tylostyles | 12 |
| 3. Tylostyles, no microscleres | 3 |
| 4. Tylostyles with microscleres | 6 |

3. Encrusting; surface red to red-orange; often with small white
zoanths; tylostyles, 205–321 by 5.1–10.7 μm *Cliona delirix*
Not encrusting 4
4. Pointed end of tylostyles attenuated or “ragged”; tylostyles,
134–221 by 7.8–11.4 μm ; tiny (0.60–0.70 mm) dull yellow
ostial and oscular papillae *C. janitrix*
Pointed end of tylostyles not attenuated 5
5. No papillary fusion; tylostyles, 207–269 by 7.2–9.4 μm ,
pumpkin-colored; oscular papillae almost twice as
large as ostial papillae *C. peponaca*
Papillary fusion; red to red-orange; wide galleries;
tylostyles, 256–404 by 6.7–12.6 μm ; depth
range, 0–5 m *C. laticavicola*
forma *laticavicola*
tylostyles, 248–324 by 5.0–9.2 μm ; depth
range, 12–17 m *C. laticavicola*
forma *parvispiculata*
6. Tylostyles, oxeads and microrhabds; tylostyles few in
number, 236–288 by 4.0–7.1 μm ; microspined oxeads,
60–116 by 2.1–4.3 μm ; spiny microrhabds, 9.2–22.1
by 1.1–2.6 μm ; vermilion; oscular papillae (0.25–
3.44 mm) larger than ostial papillae (0.18–1.48 mm) *C. lampa*
Tylostyles and spirasters 7
7. Spirasters smooth, wormlike, multiply bent, 31.8–52.7
by 2.2–4.7 μm ; tylostyles, 141–387 by 5.0–10.2 μm ;
red to red-orange; papillary perforations,
0.70–1.54 mm *C. vermifera*
Spirasters spined 8
8. Spirasters are anthosigmas, usually C-shaped, with
prominent, branched spines; size of anthosigmas,
15.4–24.9 by 1.9–2.5 μm ; tylostyles, 389–477
by 7.9–9.2 μm ; brownish tan; encrusting *Anthosigmella varians*
Spirasters multiply bent 9
9. Spirasters of two types: short and stout, 26.5–68.9
by 4.1–7.9 μm ; long and thin, 60.9–100.7
by 1.6–3.2 μm . Striking purple coloration
remains after preservation *C. schmidtii*
Spirasters of one type 10
10. Completely overgrowing substrate, usually with
small, white zoanths; sponge black–brown;
tylostyles, 303–407 by 9.0–15.9 μm ; spirasters,
28.3–35.0 by 1.2–1.8 μm *C. langae*
Not completely overgrowing substrate 11

11. Extensive papillary fusion; brown-black; tylostyles, 284–356 by 7.8–10.6 μm ; spirasters, 29.2–39.8 by 1.4–2.5 μm ; depth range, 0–5 m *C. aprica*
 forma *aprica*
 tylostyles, 276–297 by 7.7–8.2 μm ; depth range, 12–34 m *C. aprica*
 forma *profunda*
- No papillary fusion; dull yellow; tylostyles, 361–451 by 9.4–12.1 μm ; spirasters, 27.3–41.8 by 1.0–2.2 μm *C. caribbaea*
12. Spiculation of smooth oxeas, 119–148 by 6.9–9.1 μm ; lemon yellow; oscules, short prominent cylinders, 7–8 mm in height; ostial papillae often confluent, diameter 7–8 mm by 2 mm *Siphonodictyon brevitubulatum*
- Spiculation of diactinal spicules and amphisters; stout tubercled diactinals, 151–354 by 9.6–12.3 μm ; thinner, usually smooth diactinals, 186–287 by 6.1–8.5 μm ; amphisters, bearing whorl of 5–6 rays near each extremity, 31–74 by 1.4–4.3 μm ; pale yellow; tiny (0.39–0.83 mm) papillae *Alectona jamaicensis*

V. Diversity and Zoogeography of Reef-dwelling Excavating Sponges

The diversity of reef-dwelling clionids as previously reported in the literature is surprisingly low. A study by Burton (1934) of the sponges collected during the Great Barrier Reef Expedition revealed the presence of two coral-dwelling spirastrellids, *Spirastrella inconstans* (Dendy) and *Spirastrella aurivillii* Lindgren, but no clionids. De Laubenfels (1954) found five species of clionids in the west central Pacific. The West Indian shallow water sponge fauna is both diverse and colorful in most localities. Yet of the 233 species from this region listed by de Laubenfels (1950b) only two, both endemic, are clionids. One coral-dwelling spirastrellid, *Spirastrella dioryssa* de Laubenfels, was also found to be present. Studies of the sponges of the Lesser Antilles at Curaçao (Arndt, 1927) and Barbados (Hechtel, 1969) list no clionids.

From relatively recent investigations of the Porifera of the Bahamas, Bermuda (de Laubenfels, 1949, 1950a) and Jamaica (Hechtel, 1965) four species of clionids are reported: *Cliona lampa* (Bermuda), *C. vastifica* (Bahamas), *C. viridis* (= *C. caribbaea*, Jamaica) and *C. vermifera* (Jamaica). These workers also reported the presence of *Anthosigmella varians* from the Bahamas (de Laubenfels, 1949) and Jamaica (Hechtel, 1965). The low diversity of previously reported excavating sponges from the West Indies may be contrasted to the presence of nine species (three endemic) of boring sponges in the shallow waters of the Adriatic (Volz, 1939).

Thirteen species of excavating sponges from the reefs of Discovery Bay and Rio Bueno, Jamaica, are described in the present report (Table 2.) In addition, eight undescribed species of excavating sponges, not reported in this paper, have been tentatively identified from the study area. The low diversity or absence of reef-dwelling clionids in the reports of other workers is most probably due in large part to the cryptic habit of these sponges. Most excavating sponges communicate with the external environment by means of small, rather inconspicuous incurrent and excurrent papillae. The largest of these papillae may attain a diameter of 2-3 mm, but quite frequently a species will have papillae of less than 0.5 mm in diameter.

Of the six previously described species found during the course of the present investigation, three, *C. caribbaea*, *C. lampa* and *A. varians*, are apparently confined in their distribution to tropical Atlantic America. *C. janitrix* has only been described from Corsica previously. *C. schmidt*i and *C. vermifera* have been reported most frequently from the Mediterranean and Adriatic seas, but they also occur in the Indo-Pacific. One of the seven new species, *C. laticavicola*, is also found in Puerto Rico. *Alectona jamaicensis* is very close to Topsent's (1900) deep-water Mediterranean specimen of *A. millari*. The description of the new species of *Alectona* from Discovery Bay, Jamaica, represents the first report of this genus from the waters of the Western Hemisphere. It is also interesting to note that *C. caribbaea* is in many respects similar to *C. viridis*, originally described from the Adriatic by Schmidt (1862).

The faunal affinities of the Jamaican excavating sponges are apparently with those of the Mediterranean and Adriatic seas. De Laubenfels (1950b) stated that the faunal affinities of the West Indian Porifera in general are with the Porifera of the Mediterranean and the East Indies. According to Hechtel (1965) most of the 57 known species of sponges from Jamaica have a limited distribution. Two-thirds are endemic to tropical Atlantic America. He speculated that there might be a strong West African influence in the sponge fauna of the Lesser Antilles. However, a subsequent study of the Demospongiae of Barbados (1969) gave "no evidence of affinities with West African sponges" (p. 5). Most similarities are with Indo-Pacific sponges. Very little is known concerning the clionids of the Lesser Antilles.

Competition for space and the protective advantages offered by the indwelling habitus have apparently led to the acquisition of this mode of existence by several different groups of sponges, particularly within the coral reef environment. In this environment we find not only numerous species of clionids, but in addition, coral-dwelling spirastrellids and excavating species of the genus *Siphonodictyon*.

VI. Transplant Studies

Two of the new species described above, *Cliona aprica* and *Cliona laticavicola*, were found to have a deep-water and a shallow-water form that may be dis-

Table 2. Comparison of the excavating sponges described from Discovery Bay, Jamaica.

Species, color, depth	Megascleres (μm)	Microscleres (μm)	Excavations (mm)	Ostial and oscular perforations (mm)
<i>Aliona schmidtii</i> Purple 15-47 m	T: 256 X 5.4	Spirasters: 44.8 X 5.8 73.9 X 5.8	1.17 X 2.56	1.02, 1.83
<i>C. vernifera</i> Red to red-orange 1-2, 18-52 m	T: 247 X 7.4	Smooth spirasters: 43.8 X 4.0	1.64 X 3.48	1.04, 1.08
<i>C. janitrix</i> Dull yellow 15-28 m	T: 195 X 9.2	None present	5.11	0.58, 0.70
<i>C. lampa</i> Vermilion 0.5-36 m	T: 280 X 5.1 Ox: 79.1 X 3.0	Spiny microthabds: 15.3n X 2.0	1.08 X 1.58	0.72, 1.20
<i>C. caribbaea</i> Yellow 1-2 m	T: 394 X 10.2	Spirasters: 38.3 X 1.5	4.21	not measured
<i>C. delitrix</i> Red to red-orange 22-34 m	T: 279 X 8.9	None present	3.91	3.05 X 4.05, 7.85 X 9.65
<i>C. peponaca</i> Pumpkin orange 15-29 m	T: 243 X 8.9	None present	1.21	0.69, 1.11

<i>C. langae</i> Brown-black (surface) 15-33 m	T: 357 X 13.3	Spirasters: 31.3 X 1.9	2.31	Ostia: 19-23 μm^\dagger Oscules: 4-6 mm ‡
<i>C. laticavicola</i> Dull orange (surface) 0-3*; 12-20 † m	T: 349 X 10.2* 274 X 7.3 ‡	None present	46.1* 1.12 ‡	2.55*, 2.83* 2.18 ‡ , 2.54 ‡
<i>C. aprica</i> Brown-black (surface) 0-5*; 12-34 ‡ m	T: 326 X 8.4* 286 X 7.9 ‡	Spirasters: 34.1 X 1.9* 32.4 X 1.8 ‡	1.20* 1.24 ‡	Compound papillae: 1.05 X 1.67* 0.98 X 1.52 ‡
<i>Alectona jamaicensis</i> Pale yellow 14 m	Ox: diactinal spicules (a) 215 X 10.8; (b) 203 X 7.9	Amphiasters: 59 X 2.2	6.2	0.51, 0.54
<i>Anthosigmella</i> <i>varians</i> Brownish tan 20-41 m	T: 423 X 8.1	Anthosigmas: 19.4 X 2.2	2.94	Ostia: 20-24 μm^\dagger Oscules: 2-3 mm ‡
<i>Siphonodictyon</i> <i>brevitubulatum</i> Lemon yellow 5-32 m	Ox: 134 X 8.0	None present	44.7	1.71, 0.11 Confluent papillae: 7-8 mm by 2 mm

*Shallow water form

† Deep water form

‡ Completely encrusting, perforations not visible

T = tylostyles, Ox = oxaeas

Mean values given for all measurements; standard deviation is given in text

tinguished by differences in the dimensions of the spicules and papillae, the degree of papillary fusion and, to a slight degree, spicule morphology. Transplant studies were conducted with these species in an effort to determine the influence of the habitat upon the characteristics of the two forms.

Method. Transplants of excavating sponges were made following the method of Neumann (1966). The substrates used for the transplants were: calcite, Vermont marble, dead shells of the oyster, *Crassostrea virginica* (Gmelin), and uninfected branches of *Acropora cervicornis* and *A. palmata* that had been washed in fresh water to remove the living tissue and placed in running sea water overnight. Small pieces of sponge-infected coral taken from shallow (0–3 m), intermediate (8–16 m) or deep (20–30 m) water were broken open, attached to the various substrates and placed at two stations, one at 15 m on a coral island (Kinzie, 1970) in a sand channel of the *cervicornis* zone and the other at 24 m on a large coral-covered rock situated on the sand between the *cervicornis* zone and the fore reef slope. (The terminology of the reef zones follows that of Kinzie, 1970). The transplants at the 15-m site suffered considerable damage during the winter storms; unfortunately, most were lost during this period. All transplants at the 24-m site were recovered. The dates of the transplants were as follows: at the 15-m site, 16 Nov. 1969 to 25 March 1970; at the 24-m site, 25 March 1969 to 9 Nov. 1969 and 12 Nov. 1969 to 25 March 1970. The mean and range of tylostyle measurements were calculated. Fifty measurements were made for all specimens considered.

Results. The results of the transplants, discussed below, are summarized in Tables 3 and 4.

a) *Cliona aprica*. Small pieces of the shallow- and deep-water forms of this sponge were transplanted to 15 and 24 m. All but one of the transplants at 15 m were lost during the winter storms. *C. aprica* forma *aprica* from *A. palmata* at 1 m was successfully transplanted to both *A. palmata* and Vermont marble placed at 24 m. Transplants of both forms of this species on calcite and *Crassostrea virginica* failed. After 7.5 months, transplants infecting *A. palmata* and Vermont marble showed very little tendency to encrust. The original shallow-water sponge was observed to be growing over a large portion of the substrate when it was originally collected. The tylostyles of the transplants, although abundant, were quite thin and much smaller. These new spicules resembled those of *C. aprica* forma *profunda* in appearance. The spicular dimensions of the original sponge had not changed. However, the color of the papillae had changed.

Transplants of *C. aprica* forma *profunda* originally inhabiting *A. cervicornis* at 18 m to uninfected branches of *A. cervicornis* at 24 m were also successful. When examined 7.5 months later, the transplants exhibited extensive papillary fusion. The compound papillae were slightly smaller than those of the original sponge. Tylostyle dimensions of the original remained the same in each case. Tylostyles of the transplants were thinner but of a comparable length. The excavations of the transplants extended through the superficial layers of the

Table 3. Transplant studies conducted with shallow- and deep-water forms of *Cliona aprica*.

Form	Substrate & depth	Tylostyle dimensions	Papillary dimension and color	Degree of papillary fusion
<i>C. aprica</i> f. <i>aprica</i> (original)	<i>Acropora palmata</i> 1 m	281–323–352 μ m X 7.9–8.3–8.5 μ m	0.78–1.04–1.17 mm X 1.21–1.65–1.83 mm* brownish black	very extensive
<i>C. aprica</i> f. <i>aprica</i> (transplant)	<i>A. palmata</i> 24 m	243–281–301 μ m X 4.0–4.8–5.6 μ m N = 3	0.46–0.48 mm† 0.49–0.51 mm‡ pale gray	very little
<i>C. aprica</i> f. <i>profunda</i> (original)	<i>A. cervicornis</i> 18 m	253–279–291 μ m X 6.8–7.0–7.2 μ m	1.36–1.61–1.80 mm X 1.77–1.98–2.06 mm*	extensive
<i>C. aprica</i> f. <i>profunda</i> (transplant)	<i>A. cervicornis</i> 24 m	251–276–289 μ m 5.5–6.1–6.6 μ m N = 3	1.29–1.40–1.56 mm X 1.53–1.71–1.88 mm	extensive
*compound papillae				
†ostial papillae				
‡oscular papillae				

TABLE 4. Transplant studies conducted with shallow- and deep-water forms of *Cliona laticavicola*.

Form	Substrate & depth	Tylostyle dimensions	Papillary dimensions	Degree of papillary fusion
<i>C. laticavicola</i>	<i>Porites porites</i>	301-346-389 μm	2.07-2.33 mm †	extensive
<i>C. laticavicola</i> (original)	1 m	X 9.1-11.2-12.6 μm	2.37-2.51 mm ‡	
<i>C. laticavicola</i>	<i>Acropora palmata</i>	119-260-283 μm	0.84-1.20 mm †	none
<i>C. laticavicola</i> (transplant)	24 m	X 2.9-3.2-3.7 μm	0.90-1.80 mm ‡	
<i>C. laticavicola</i>	<i>A. cervicornis</i>	253-283-324 μm	1.20-1.82 mm †	some
<i>C. laticavicola</i> (original)	18 m	X 6.8-7.6-8.2 μm	1.80-2.11 mm ‡	
<i>C. laticavicola</i>	<i>A. cervicornis</i>	269-281-318 μm	0.84-1.01 mm †	some
<i>C. laticavicola</i> (transplant)	24 m	X 3.9-4.4-5.6 μm	0.90-1.20 mm ‡	

† ostial papillae

‡ oscular papillae

branches of *A. cervicornis* for a length of 7.1–8.3 cm. One transplant of the deep-water form of *C. aprica* to Vermont marble placed at the 15-m site survived the winter storms. Spicular dimensions of the transplant were comparable to those of the original sponge, although the tylostyles were slightly thinner.

b) *C. laticavicola*. When small pieces of the shallow-water form of this species, originally inhabiting *P. porites* at 1 m, were transplanted to uninfected branches of *A. palmata* placed at 24 m, small elliptical excavations, 2–3 mm by 1 mm (long axis by short axis; three specimens), were produced in the new substrate. The excavations in the original substrate were irregular and circular with a diameter of 1.0–1.3 cm. In the new substrate, the perforations through which the papillae protrude were considerably smaller than those of the original sponge. Papillary fusion, extensive in the original sponge, was not observed to occur in the transplant. The tylostyle dimensions of the original sponge remained unchanged. The tylostyles of the transplants were very much shorter and thinner than those of the original.

Small pieces of *C. laticavicola* forma *parvispiculata* inhabiting *A. cervicornis* from 18 m were attached to uninfected branches of *A. cervicornis* and placed at 24 m for 7.5 months. The transplants excavated a series of cylindrical galleries, 2–3 mm in diameter, extending throughout the central axis of the coral for a length of 2.0–3.5 cm. The excavations of the original, also cylindrical, were 1.1 cm in diameter and filled the central axis of the infected branch for a length of approximately 10 cm. The tylostyles of the transplant were comparable in length to those of the original, but were thinner. Papillary perforations of the transplants were also smaller than those of the original sponge. Transplants of the shallow-water and deep-water forms of *C. laticavicola* to *Crasostrea virginica* and calcite failed.

Previous investigators, dealing with seasonal variation among natural populations or with gemmules grown under laboratory conditions, have also found that environment parameters may affect spicular dimensions. Early experimental work by Jørgensen (1944, 1947), using the fresh-water sponge *Spongilla lacustris* (Linnaeus), showed that an increase in the silica concentration of the medium resulted in an increase in the uptake of SiO_2 by the forming spicules. He reported (1944) that thicker microscleres were formed in a medium containing more silica. The length, however, was not affected.

Hartman (1958) found that in natural populations of the marine sponge *Haliclona canaliculata* Hartman winter colonies possess thicker spicules than summer colonies, and suggested that this might be due to the greater availability of silicates in New England waters throughout the winter months. Stone (1970) was able to correlate seasonal changes in the spicules of *Hymeniacidon perleve* (Montagu) with the changing levels of environmental silicates in British coastal waters.

Recent laboratory studies conducted by Elvin (1971) using gemmules of *Ephydatia muelleri* (Lieberkühn), a fresh-water sponge, are in agreement with those of Jørgensen, and show that the rate of silica deposition is increased when the silicic acid concentration of the medium is increased. Although the rate of growth in spicule length decreases with an increase in silica concentration, the

projected final length of spicules in media of higher silica content would be longer than those in lower concentrations.

It is suggested that the differences in spicular dimensions observed in the shallow-water and deep-water forms of *Cliona aprica* and *C. laticavicola* may be due to differences in the concentration of available silicates in the environments inhabited by these forms.

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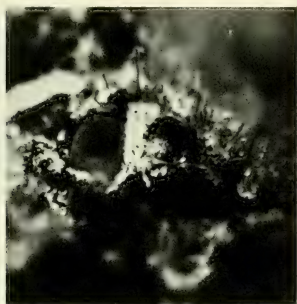
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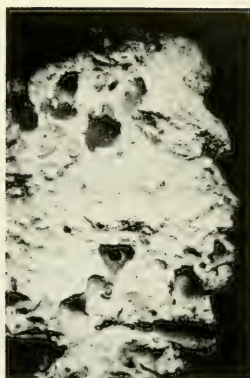
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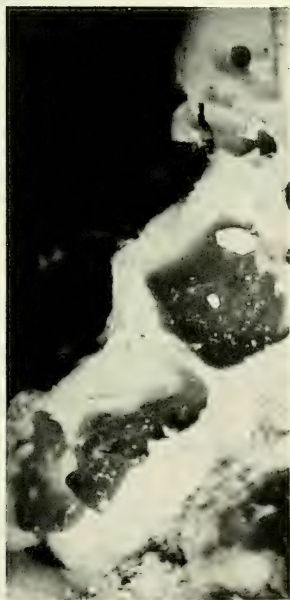
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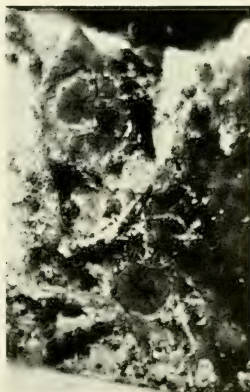
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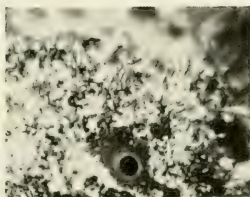
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Fig. 17. Oscule of *Cliona lampa* de Laubenfels inhabiting dead coral. Scale = 2 mm. Fig. 18. Excavations of *Cliona lampa* inhabiting dead coral. Scale = 5 mm. Fig. 19. Excavations of *Cliona vermicifera* Hancock. Scale = 3 mm. Fig. 20. Ostial and oscular (lowermost edge) papillae of *Cliona vermicifera* Hancock. Scale = 3 mm. Fig. 21. Oscule of *Cliona aprica* n. sp. forma *aprica* inhabiting dead coral. Scale = 3 mm.

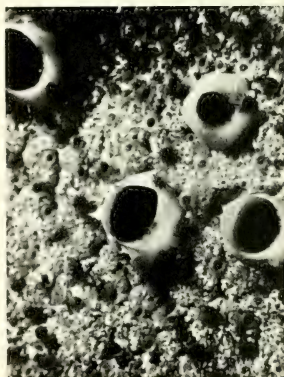
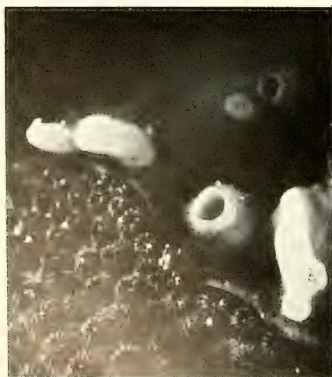
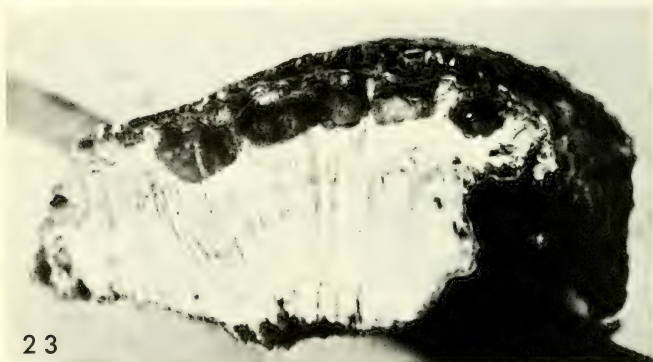
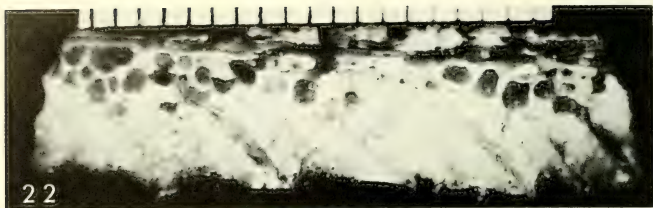


Fig. 22. Excavations of *Cliona lampa* de Laubenfels in *Acropora cervicornis*. Scale in mm. **Fig. 23.** Excavations of *Cliona laticavicola* n. sp. forma *laticavicola* in *Diploria*. Ca. 0.5X. **Fig. 24.** (right) Oscule and discrete and confluent ostial papillae of *Siphonodictyon brevitubulatum* n. sp. inhabiting *Montastrea*. The papillae are surrounded by a red encrusting sponge. Photograph by H.M. Reiswig. Scale = 3 mm. **Fig. 25.** Oscules of *Cliona delitrix* n. sp. Epizoic zoanthids, *Parazoanthus parasiticus* (Duch. & Mich.), may be seen growing in the sponge surface. Photograph by H.M. Reiswig. Scale = 1 cm.

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